MATERIALS

FOR

OBJECT LESSONS

BY

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PREFACE

It will be seen from the title that the object of this book is not to give instruction in the science and method of teaching. It is rather to put before a teacher such definite information as will enable him, with a minimum of reading, to give a lesson on any of the subjects treated.

This information can, of course, be collected from original sources by any one who has leisure, and the Author claims no merit for originality. But it is exactly this leisure which the teacher, under ordinary circumstances, most lacks. Especially is this the case with the youth, who, besides his six hours' daily work in school, has so many specific subjects of study to occupy his other waking hours that he fears to give any time to general reading, lest he may endanger his success at the always approaching examination.

It may seem superfluous to say that a teacher should know something of the subject upon which he is required to talk to his class. Some experience, however, in listening to lessons given by young teachers has convinced the Author that not only inaccurate statements, but also faults of manner and style, are very often attributable to a want of knowledge, coupled with the teacher's consciousness of this deficiency, and the consequent dread that his little store will too soon be exhausted. This is, of course, not always the case, and faults are sometimes due to a state of things quite the reverse of that just referred to. Thus a teacher may be so full of his subject that he may be led to proceed too rapidly, and to attempt too much. Such teachers are, however, not nearly so commonly met with as those for whose wants this book is intended to provide.

The 'materials' for each lesson have been arranged under separate heads in such a manner that they may be easily mastered; and here and there, under each subject, will be found references to sources of fuller information.

Words will occasionally need explaining, although simplicity of language has been, as far as possible, studied, and the practice of

introducing long words merely for the sake of giving definitions has been carefully avoided.

Only such woodcuts have been inserted as can be readily reproduced on the black-board, and these only where illustration seemed advantageous. Specimens of the actual thing forming the subject of the lesson (for example, apple, potato, raw cotton, silk, &c.) should be shown wherever possible, and pictures in all cases.

Stories of animals have not been introduced, except where they aptly illustrated some peculiar habit or characteristic. The teacher will find a good collection of well-selected stories in *Kindness to Animals*, published by W. & R. Chambers; and in *Animal Intelligence*, by G. Romanes, published by Kegan Paul & Co.

As already stated, instruction in 'method' has been purposely omitted. Teaching is an art which is acquired, by those who have the natural capacity for its acquisition, chiefly by imitation. Many of the most successful teachers of to-day attribute their success to the example in the past of some able master. In the absence of such example and practical illustration of the art of teaching, the most elaborate rules to be learned from books as to the cultivation of this or that mental faculty are beside the mark, and valueless. As, however, young teachers are required at certain of their examinations to write out 'notes of a lesson' on some given subject, it has been thought that this book would be made more useful if specimen notes of lessons were added on four or five typical subjects. Accordingly, such notes have been written on 'Water,' 'The Horse,' 'Air,' 'The Apple,' and 'The Farmer.'

C. M.

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APPENDIX.

MATERIALS FOR OBJECT LESSONS.

WATER.

General Description:

1. Water is called a *fluid* because it flows over the side of the glass or other vessel in which it is contained when tilted.

2. Being fluid, it has no shape of its own, but fits itself to the form of the vessel into which it is poured.

3. It presses in all directions; for water will run out of a hole in the side of a pail as well as from one in the bottom. That it presses upwards may be shown by noticing that solid bodies lose weight when immersed in water, and so weigh less in water than in air.

Action of heat upon water:

1. If water be warmed, it expands more and more until it boils and is changed into steam, which fills about 1700 times as much space as the water from which it was produced. The boiling-point at the level of the sea is 212° Fahrenheit, and varies according to the pressure of the atmosphere. If

we go up a mountain, where of course the pressure of the air gets less as we ascend, water boils at a lower temperature than 212° F. Boiling-point is lowered 1° F. for every 590 feet above the sea level.

2. If water be chilled greatly, it is changed into ice. The point at which this change takes place is 32° F., and is called freezing-point. While water is being chilled, it gradually contracts until it is about $7\frac{1}{2}$° above freezing-point. From $39\frac{1}{2}$° F. down to 32° F. it expands, so that ice does not weigh so much as the same bulk of water. For this reason ice floats.

3. Water at $39\frac{1}{2}$° F. is therefore heavier than the same volume of water at any other temperature—that is, a pint at $39\frac{1}{2}$° would weigh more than a pint at 33°, 50°, or any other temperature.

Hence $39\frac{1}{2}$° F. is said to be '*the point of greatest density of water.*'

(See *Elementary Chemistry*, by H. Roscoe.)

Sources of water.—All the water with which we have to do is perpetually circulating. From sea and from land it is raised as a pure invisible vapour; it forms clouds, and it falls as rain, dew, mist, snow, and hail. All the rain that falls upon the earth washes something or other from the rocks, and carries it down through streams and rivers to the sea. Though the watery vapour which comes from the sea is pure, the sea is really the great sink of the world, into which everything drains. A great deal of the refuse materials, however, is constantly being drawn away from the salt water by the animals living in it, and in this way the sea is purified.

1. *Rain water.*—This is often smoky and unwholesome. As the raindrops descend through the air they take up the floating particles of dust and dirt, and they dissolve several gases, some of which may be harmful. Thus rain water is

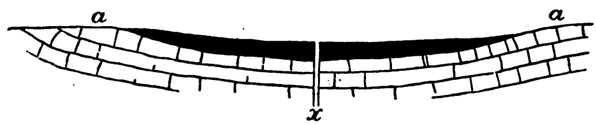
often impure before it has touched the earth. It becomes much more so, however, after it has fallen. Even on a slate or tiled roof, it takes up some little decaying vegetable matter. On a lead-covered roof or a galvanised iron roof it takes up lead or zinc, and both these metals are injurious when present in drinking water.

2. *River water.*—When rain falls upon fields, or upon the streets of towns and villages, it becomes polluted with many impurities—refuse of plants and animals; sewage matter from houses; and decaying animal and vegetable substances. When it reaches rivers, the water is often made worse by foul waste matter from factories. Yet in spite of all this, a running stream sometimes gets purified as it flows along—partly by the materials of the rocks over which it passes, and partly by the air contained in it, for the oxygen in the air quickly burns up (or oxidises) the impurities.

Water-supply of London.—Nearly all London is supplied with water from the Thames and from its tributary the Lea. In 1877 the daily amount of water delivered in London was 114 millions of gallons, and in 1884 about 140 millions. This water is carefully filtered before delivery; but its purity is much impaired by inattention to the condition of the tanks and cisterns in which it is received and stored.

3. *Wells and springs.*—Besides the water on the surface of the earth, which is evaporated quickly back again into the air, and that which runs into the sea by rivers, a large portion of the rain sinks into the earth, and finds its way through cracks and joints of the rocks, and reappears sooner or later in springs and wells. The earth's crust is formed of various kinds of 'rock,' as it is called geologically, some of which, like sand and gravel, allow water freely to pass through them, while others, such as granite and clay, will not admit of its passage.

A common way in which springs are formed is shown in the figure, where sand underlies clay. Water sinks into the



sand at *a*, and this accumulates at *x*, for it cannot get through the clay. If a well be sunk near *x*, the water will rapidly rise.

(See *Text-book of Geology*, by A. Geikie, p. 346; also *World of Waters*, by R. Zornlin.)

(*a*) *Surface well water* is not good for two reasons: (1) because impurities from stables, pigsties, graveyards, and similar places, easily reach such wells, and are apt to cause disease; (2) because the few feet of gravel or sand through which the liquid passes is insufficient to remove these impurities.

(*b*) *Deep well water* is much more wholesome if soakage from above and leakage from the sides of the well be guarded against. The impurities which the rain has carried down are rendered harmless by having to pass through great thicknesses of earth or rock-fissures. For this reason deep well water is comparatively pure, and because of the carbonic acid gas it often contains, it is also pleasant to the taste.

The need of water for drinking purposes:

1. *To supply the amount lost by the human body.*—The body of every human being consists very largely of water. If we suppose a man to weigh 150 lbs., there is contained in his bones, flesh, blood, brain, liver, and even fat, more than 100 lbs. of water. All day and night we are losing water from the skin; and every time we breathe we throw off

water in the form of vapour, so that our food must contain a great deal of water if it is to keep us alive. Men have been known to endure absolute privation of food for some weeks; but four or five days of absolute privation of drink (except in a moist atmosphere) would be fatal.

The feeling of thirst comes on in a healthy body when about 1 lb. of water has been lost. A healthy man loses about 6 lbs. 3 oz. of water daily. He need not take in more than 5 lbs. 8 oz., because about 10 oz. of water are actually formed in the body—for the hydrogen, which is contained in such foods as fat and sugar, unites with the oxygen of the air and produces water. The amount required is increased if our food is salt or highly seasoned, and after violent exertion, or if the pulse is high or the digestion imperfect.

2. *To remove waste matters from the body.*—One of the most injurious of these is called **urea**. It is formed in the body, and would remain and poison the blood if it were not thrown out by the kidneys, and this is done through the help of a large quantity of water—about three pints in twenty-four hours—which washes this substance out of the blood.

The removal of another poisonous substance—the gas called **carbonic acid**—about 2 lbs. of which pass from the lungs every day, is aided by watery vapour.

3. *To keep down the temperature of the body.*—This is done by the escape of water from the skin in the form of perspiration.

Impurities of water:

1. *How to detect them.*

Good water should be clear and bright. It should show no cloudiness; and when shaken, bubbles should rise and break directly.

Good water should be without smell, whether it be cold

or hot, and it should be free from smell when kept in clean vessels.

Good water should be without distinct taste. Its pleasantness to the palate will depend upon the amount of gas it contains.

Good water should be of a pale blue tint. This may be seen by filling a large white jug quite up to the brim.

After water is boiled down, some solid substances are left behind. The amount of these varies in different waters. If it is yellowish, and shows gum-like stains on the dish in which it has been boiled, these stains will, on being heated, very likely darken, burn away in part, and give out a disagreeable smell. If this smell is like burnt feathers, then it is certain that organic impurities are present, and probably of animal origin.

Impure water will take away the beautiful purple colour of a few drops of Condy's fluid. If there is much organic impurity present, the colour will go directly, and more of the fluid may be added and still lose its colour.

2. *How to remove them.*

Impurities exist in water in two forms—floating and dissolved. The coarser particles settle of themselves when the water is left at rest, but the smaller ones need to be strained or filtered off.

The best materials for filters are

Gravel and sand.
Charcoal, especially burnt bone.

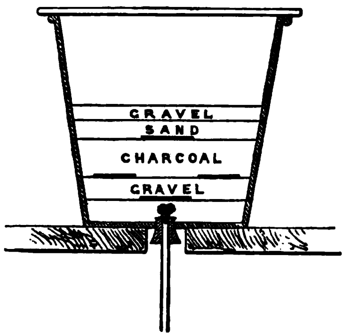
The charcoal does more than keep back the floating impurities—it removes some of the dissolved substances as well. This it can do partly owing to the large amount of oxygen which it has stored up in its pores.

A cheap filter may be made thus: Take a large flower-pot and soak it thoroughly in clean water. Plug up the

hole with a cork and glass tube, into the upper end of which force a little piece of sponge. Now put into the pot—

An inch of clean sand.
Two inches of clean gravel.
Four inches of animal charcoal.
Another layer of sand.
Another layer of gravel.

Slips of glass placed on the different layers will prevent the water from running too quickly through the filter.



Good filters are often used now which are provided merely with a block of compressed carbon. When this gets clogged up with dirt it may be scrubbed or gently scraped, and then cleansed by passing through it water in which some purple Condy's fluid and a little hydrochloric acid have been mixed. All filters require to be cleaned at short intervals. Neglect of this precaution is a constant source of disease.

Water for washing.—The rain which has fallen upon limestone rock dissolves lime and carries it along. Owing to this the water has a harsh feeling when used for washing the hands, and it throws the soap into a curd on the

surface of the water. Hardness in water is a great disadvantage. Linen washed in hard water becomes of a bad colour, and when washing the body in it, the skin gets clogged with useless curdy matter. Good tea or coffee cannot be made with it, and in making soup more meat is required with hard than with soft water.

There are two ways of getting rid of this hardness:

By boiling.—This causes the limy materials to separate from the water, and to form a fur on the boiler or kettle.

By adding more lime to the water.—Slake 18 ounces of freshly burnt quicklime in a little water. When the lime has fallen to powder, add enough water to make a thin cream, and stir the mixture in a pail. This thin cream will soften 700 gallons of hard water—for it unites with the lime already in the water, and so both fall to the bottom.

(See *Plain Words about Water*, by A. H. Church.)

MILK: BUTTER AND CHEESE.

General.—Fresh milk is a white liquid slightly heavier than water. It has a sweet taste and an agreeable smell. Because there is a multitude of minute particles of fat floating in milk, it cannot be seen through as water can. It is therefore said to be *opaque*. As milk forms the only food of the young of a certain class of animals, it is the best example of a perfect food. The amount consumed in the British Islands is not a pint per head of the population each day. In Arabia and Switzerland and some of the mountainous countries of the East, the inhabitants take as much as seven pints a day per man.

Composition.—The ingredients of milk are:

1. Water.
2. Those substances of which cheese is chiefly composed.
3. The fatty substances which form butter.
4. Sugar of milk.
5. Minerals.

Cow's milk, when new, contains in 100 parts:

4 parts of cheese-forming substances.
4 parts of fat.
5 parts of sugar.
1 part of minerals.
86 parts of water.

Adulteration of Milk.—If water be added to milk, or cream taken from it, the fact can often be discovered by use of either the lactometer or the lactoscope.

The **lactometer** is a long glass tube marked with a scale, from 0 at the top to 100 at the bottom. It is filled with the milk to be tested, and then allowed to stand until the cream rises. Generally, the cream extends to the 8th or 9th mark, and sometimes even to the 20th. If it does not reach the 5th, it may be concluded that either water has been added or cream has been removed.

The **lactoscope.** By this instrument, a lighted candle is looked at through a layer of milk contained in a glass vessel with flat sides. One of these sides being movable, the thickness of the layer of milk can be readily increased. It is increased until the candle can no longer be seen. The thicker the layer through which the light is visible, the poorer is the milk; for the less must be the floating fatty particles which it contains.

Effect of food upon the milk.—Milk is influenced by the kind of food the cow eats. Thus the colour may be

modified by mixing saffron or madder with the food. The odour is affected when plants belonging to the cabbage and onion tribes are eaten; and the taste by such bitter articles as wormwood. Sometimes, too, when poisonous plants are consumed, the milk will acquire poisonous properties without the animals themselves (the cows, goats, sheep, &c.) being poisoned. In the autumn, the milk of meadow-fed cows sometimes has an unpleasant flavour, owing to the fallen and decayed leaves which may happen to be eaten by the animal.

With good dry food, the milk becomes richer in solids, whilst with good grass it abounds in fat. Oil-cake also will increase the quantity of solids; but for the cow, no food is so good as the fresh pasture of the country fields.

Chief varieties of milk used by man:

1. **Cow's** milk is the most used throughout the world. It is not always of the same quality. Certain kinds, such, for instance, as the Alderneys, give a large proportion of butter as well as plenty of milk; others, a large proportion of cheese, and so on. There is no milk so agreeable to the taste as cow's milk, for while it has a fuller flavour than that of the ass and the mare, it has not the strong flavour of the milk of the buffalo or goat, and it is not so surfeiting as that of the sheep.

2. **Ass's** milk contains more water and sugar than cow's milk, and less fat and other materials. It is therefore suited for people who are too delicate to take cow's milk.

3. **Mare's** milk is used more commonly in Turkey than that of the cow. It is like the milk of the ass, but sweeter. So large is the amount of sugar which it contains, that in Russia it is fermented, and converted into an intoxicating drink called *koumiss*.

4. **Sheep's** milk is thicker than that of the cow, and contains more butter and cheese-forming materials.

Uses:

1. **Butter.**—When milk is allowed to remain undisturbed for some hours, it separates into two parts—the **cream** which rises to the surface, and the **skim-milk** which remains beneath. The cream is formed of small particles of fat, each inclosed in a thin skin. In churning, this skin is broken, and the oily particles unite together into a solid mass of **butter.**

When the butter is formed, it is taken out of the churn and well kneaded and washed with water, to remove as well as possible those parts which before composed the covering of the oily globules. For if they be left behind, they decompose, and make the butter rancid. The more completely they are removed, therefore, the better will the butter keep. Salt preserves these substances from decomposing, and is on that account usually added to butter. In certain kinds of American salt butter there are added to every 22 lbs. of butter, 16 ounces of salt, one teaspoonful of saltpetre, and a tablespoonful of powdered white sugar.

(For description of butter-making in the United States, see Dr Smith's book on *Foods*, pp. 129–133.)

Buttermilk is the liquid portion of the cream which is left after the butter is made. It is said to be more valuable than the skim-milk, although often not thought so by the country peasants. It is much used by the labourers in Ireland, Wales, and Scotland, and with potatoes or porridge forms an agreeable and nourishing diet. In India, too, buttermilk is largely used. There is a saying among some Indian tribes that 'a man may live without bread, but without buttermilk he dies.'

2. **Cheese** is formed of the **curd** of milk. This is separ-

ated from the other ingredients by adding to milk generally a substance called **rennet**, which is obtained from the stomach of the calf. In Holland, an acid is used instead. The curd, in separating from the rest, entangles and carries with it the suspended fat globules of the milk. This curd is then collected into a mould of the shape the cheese is intended to be. Here it is pressed, in order that as much as possible of the liquid portion may be squeezed out. When hard enough, it is turned out and placed in a warm room to dry. Every day or two it is turned over, and at the same time is kept perfectly clean. The quality of the cheese depends upon the amount of fatty matter present in the milk from which the cheese is made. In the richest cheeses, as Stilton and double Gloucester, cream is added to the milk. Cheshire cheese is made from unskimmed milk; single Gloucester and American, from milk with a little of the cream removed; and Dutch, Parmesan, Suffolk, and Somersetshire, from skimmed milk. It is this poor cheese from skimmed milk which is found to keep the best.

The natural colour of cheese is dingy white. When it is of a bright hue, there has been an addition of some colouring matter. The green colour of Stilton is due to a vegetable growth; but some kinds of cheese are coloured green by powdered sage leaves.

Cheese is very nourishing, but is hard to digest, the poorer and closer kinds especially. The stronger tasted and more ready to crumble a cheese is, the easier is it to digest. Toasted cheese is one of the most indigestible things that can be eaten.

Cream-cheese consists of the fresh curd which has been moderately pressed. It has but little flavour of cheese if eaten in a fresh state. Generally, it is kept for some time before being eaten, and then it is found to be more digestible than ordinary cheese.

Whey is what is left of the milk after the curd is separated from it. It contains the sugar, acids, and salts of the milk. It is not very nourishing, but is sometimes found an agreeable drink to feverish patients.

TEA.

The tea-plant:

1. *Description.*—The shrub, of which tea forms the dried leaves, is a native of China, Cochin-China, and Japan, and is now also largely cultivated in some parts of India. Its flowers are white, with the central part yellow, and are very much like the camellia. The leaves are lance-shaped, with saw-like teeth at the edges, and from two to five inches long.


Tea-plant.

2. *Planting.*—The seeds from which the plants are to be grown, are kept through the winter in moist earth, and sown in March. They are generally placed about five feet apart. They require good manuring and cultivation, and should be on hillsides, with good drainage, and plenty of sunlight.

3. *Pruning.*—The plant would grow to the height of thirty or forty feet, and have a stem more than a foot thick; but by pruning, it is kept down to a height of three feet, and made to grow bushy.

Gathering of leaves.—The first crop of tea is not gathered until the plants have been growing for three years. The earliest pickings of the youngest leaves take place in April. These do not amount to much, and the tea thus gathered is generally sent by caravans to Russia, and for which two guineas a pound are often charged. The Chinese reserve the greater portion of these early pickings for their own use and as choice gifts for their friends. Although very strong to the taste, this tea scarcely colours the water in which it is steeped. The later pickings take place in May or June. Women and children pluck the leaves, with a little of the stalk to which each is attached; but all old or large leaves are left upon the tree. A woman accustomed to the work will gather sixteen or twenty pounds-weight of leaves in a day.

Drying and preserving.—The leaves are dried in pans heated by straw or charcoal fires. They are moved by hand, or the pan is shaken from time to time, so that all are equally heated. After a few minutes' roasting, the leaves are rolled between the hands, and again thrown into the drying pan. Both green and black teas may be produced from the leaves of the same plant. The difference is obtained by different methods of preserving. If green tea is required, the leaves are very rapidly dried and rolled. Sometimes Prussian blue, indigo, and copperas are added, to give additional colour. This is only done, however, when the tea is to be exported, for the Chinese themselves will not drink dyed tea. Black tea is produced by allowing the leaves to lie in heaps for ten or twelve hours, and then tossing them about until they become soft. After this they are dried slowly over charcoal fires.

(See *Chemistry of Common Life*, by Johnston, chap. vii.)

Varieties of teas.—Several different sorts of tea are produced, and usually get distinctive names, sometimes from the districts in which they are grown. The principal varieties of Chinese black tea are Bohea, Congou, Souchong, and Pekoe. Of green tea the best known are Hyson and Gunpowder. Some teas have a special odour owing to the district from which they come. The Chinese, too, scent some kinds with various flowers, such as the rose, jasmine, and orange blossoms. These flowers are mixed, when fresh gathered, with the tea, and allowed to remain for twenty-four hours—after which they are sifted out.

Tea-making.—Water while boiling is poured over the leaves. The infusion should not be allowed to remain long; as by stewing, the tea loses its best flavour. In China the tea is often made in the cup from which it is drunk. In Japan the tea leaves are ground to powder, and after pouring in the boiling water, the mixture is beaten up until it becomes frothy, and is then drunk. Tea is generally measured out for use by a spoon; but some teas are much heavier than others, so that a teaspoonful of one may contain really more than the same measure of another tea. Thus a teaspoonful of gunpowder tea was found to weigh 123 grains, when the same measure of black tea weighed only 39 grains.

We put into our tea sugar and milk. The Chinese, however, drink it pure, and a great traveller in China relates that he only once met with sugar and a teaspoon. In Russia the juice of lemon is squeezed into tea, and used instead of milk or cream.

Among the Germans, who take tea very weak, a common practice is to add rum, cinnamon, or vanilla.

Effects of tea:

1. To increase a little the frequency of breathing.

2. To induce perspiration, and so to cool the body.

3. To assist in the absorption of food. It is on this account more suited for the well-fed, than for the poor and fasting. It should not be taken without food; nor by the young or very feeble.

4. To clear the mind and promote wakefulness. For this purpose, tea which has been poured off the leaves, and kept hot, is the most powerful.

5. To enable exertion to be made more easily. It should, however, be borne in mind that tea by itself is not a food.

History of the use of tea.—Tea appears to have been used from the very earliest times in China, and to have been introduced into Japan about the beginning of the ninth century. It was brought by the Dutch East India Company to Europe in the seventeenth century. In 1664 A.D. the queen of England was presented with two pounds of it as a rare gift. Now it can be had at two shillings a pound, and is consumed by half the whole human race.

COFFEE.

The coffee-plant:

1. *Where produced.*—It was originally a native of Abyssinia and Arabia; but now is grown over a large part of the tropics, including Bourbon, Demerara, Sumatra, Java, West Indies, Ceylon, Brazil, and Natal, and in some of the hothouses of this country.

2. *Description.*—The plant is kept down by pruning to a height of about six feet. It has dark smooth leaves and pale white flowers. The latter have a delicious fragrance, and quickly fade away. The fruit left after the flower dies

is a dark red berry, which, when ripe, is very much like our cherry. Instead of the stone, however, as in the cherry, the coffee fruit contains two flat seeds or beans. These coffee-beans are surrounded by a thick leathery skin called parchment, and by a fleshy pulp.

The coffee-plant requires a good deal of moisture while growing; but when the plant begins to ripen, the water-supply can be cut off. It grows best on hillsides, in much the same way as the tea-plant.

Coffee-plant.
b, Section of Berry.

Gathering and preparation of the berry:

1. The berries are collected either by shaking them from the trees, when only the ripe ones fall, or by gathering them by hand. The latter is the most common practice. Each labourer is expected to bring in about two bushels of berries a day.

2. These fresh, ripe berries are next bruised between rollers, and the thick pulp is got rid of by passing through sieves which keep back the beans. The beans are now washed in water and dried.

3. The parchment covering of the beans is removed by a heavy wooden wheel, which touches the coffee just sufficiently to break the skin without injuring the bean. After

having lost its tough covering, the coffee-bean is seen to be oval in shape, flat on one side, and rounded on the other; the flat side having a furrow running along its length. It has a yellowish, bluish, or greenish colour, and possesses very little taste or smell.

The coffee-beans produced by different countries differ somewhat in character and appearance. The bean of Mocha or Arabian coffee, which is considered the best in the world, is small and round, and of a yellow colour. West Indian coffee-beans are of a greenish-gray tint, and have their ends rounded. Java and East Indian coffee is large and of a yellowish-green colour.

Roasting.—The raw bean has scarcely any taste or smell. Both are given to it by roasting. This operation is performed by placing the beans in a sheet-iron or iron-wire cylinder, which is revolved over a fire, so that all the beans may be exposed in turn to the same heat. The colour of the bean changes to yellowish-brown, chestnut-brown, and black, according to the degree of heat. The proper degree of roasting is considered to be reached when the bean has become of a bright chestnut-brown colour. Coffee should be made use of soon after roasting, as it loses its flavour by keeping. In England, the roasting is carried on in large factories; but on the Continent it is often done in the house, a little at a time as required. The roasted bean has next to be ground into powder, after which the coffee should either be used at once or should be kept in a well-closed bottle or tin.

Coffee-making.—Two things have to be aimed at:

1. To extract the greatest amount of flavour and body; and
2. To render the fluid quite free from grounds.

The old practice in England was to place the coffee-pot over the fire for the coffee to boil; but this is not done nowadays,

for it is thought that by boiling, the coffee loses some of its flavour. The approved way at present of preparing this beverage is to have the coffee so inclosed that the grounds shall not escape; and then to allow boiling water to flow through it. The coffee thus made is clear and of good flavour. As in the case of tea, soft water is the best to use.

Effects of coffee:

1. It makes the breathing and the beat of the heart more rapid.

2. It does not increase the action of the skin to the extent that tea does, and therefore helps to retain the heat of the body.

For these two reasons, coffee is a more suitable drink for the poor and feeble than tea is. It is also more fitted for breakfast, because the skin is then active, and the heart's action is not so strong, as later in the day.

3. It produces wakefulness, but not so powerfully as strong tea.

4. It enables arduous exercise to be better borne; and hence to those actively employed, as soldiers on service, it is of great value.

5. Strong coffee often causes undue wakefulness and trembling in the weak and delicate, and by such people therefore strong infusions should be avoided. Coffee, like tea, is not a food.

(See *Foods*, by Dr E. Smith, pp. 365–368.)

Chicory has been for about a century used with coffee. The mixture was probably made at first because of its cheapness; but chicory is in several respects like coffee. The plant belongs to the same order as the lettuce and the dandelion, and is cultivated in England, Belgium, Holland, Germany, and France. It has a large, white, parsnip-like root which contains a bitter juice. The root is taken up

before the plant flowers, and is washed, sliced, and dried in a kiln. It is then roasted in iron cylinders which are kept revolving over a fire, just as in the case of coffee. Lard, burnt sugar, or some other substance, is added in most cases. The roasted chicory is then ground into powder, and makes a drink not unlike coffee in flavour and colour. In some parts of the continent, it is used as a substitute for coffee. Its presence may be detected by putting the coffee which is suspected of containing it, into *cold* water. If chicory is present, the water will be coloured. If only coffee is there, the colour of the water will remain unchanged.

History of the use of coffee.—The roasted bean of the coffee-plant has been in use in Abyssinia from the very earliest times, and is at the present day largely used there. In Persia, it is known to have been used for more than a thousand years. It was introduced into Arabia from Abyssinia in the beginning of the fifteenth century. Little more than a hundred years afterwards, it began to be used in Constantinople, and although forbidden by the priests as an unlawful drink, its use soon became general. In the year 1652, the first coffee-house was opened in London, by a Greek. At the present time, coffee is largely consumed by the inhabitants of every country of Europe, especially the Turks, who drink it at every hour of the day. They take no sugar or cream with it, and use no pains to purify it from the grounds. There is a sort of coffee used in Turkey, not known in this country, and called the Sultan's coffee. It is made from the external part of the berry, and is found to be less heating than the coffee prepared from the bean.

BREAD.

Flour.—When the grain of wheat is crushed between the stones of the mill, and then sifted, it is separated into at least two parts, the **bran** and the **flour**. The bran is the outside hard part of the grain. The flour contains two chief ingredients, **gluten** and **starch**. They may be separated in the following way. A piece of muslin is tied over a basin, and upon it is placed some flour. A stream of water is now poured over the flour while it is stirred about with the hand. By-and-by, the dough thus formed has become very sticky, and the water passing into the basin has ceased to be milky. This sticky dough which is now left upon the muslin strainer, is gluten. After the water in the basin has been allowed to stand for some time, it becomes clear, and a layer forms on the bottom. This sediment is starch.

A sack of flour weighs 280 lbs., and from this 90 or 94 loaves, weighing 4 lbs. each, may be made.

Preparation of the ferment.—Carefully selected mealy potatoes are well washed, and then boiled without peeling. After they have been boiled thoroughly, they are mixed with water and put into a tub, and brewer's yeast is then added with a pound or two of flour. This mixture is kept warm, and continues to rise for about five hours. At the end of that time the head falls in, and the ferment is allowed to remain quiet for two or three hours longer.

About 6 or 8 lbs. of potatoes, with a quart of brewer's yeast, are used for every sack of flour.

Preparing the sponge.—About a quarter of the whole of the flour which is to be used, is now placed in the trough, and the ferment is added along with some

warm water. The ferment is strained through a sieve, so as to keep back the potato skins. The 'sponge' (as the baker calls the mass which rises in consequence of the carbonic acid gas of fermentation) is then allowed to ferment, and at the end of five hours the mass, having risen to its full extent, breaks and falls down. It commences to rise again, however, and in about an hour it breaks once more. This is called the 'second break,' and now the rest of the flour and more water are added.

About sixty quarts of water are added for every sack of flour that is used.

Preparing the dough.—To the above mixture there is now added the salt. About 3 lbs. of salt are used to a sack of flour. This amounts to about half an ounce for every four-pound loaf of bread. The dough is worked about and thoroughly well mixed either by hand or by machinery. It is then left for an hour in order to rise again; after which it is scaled, that is, cut and weighed off in proper quantity, and made up into loaves. These are then put into the oven and heated for an hour and a half.

(See 'Lectures on Bread-making,' by Dr Graham, in *Journal* of Society of Arts, vol. xxviii.)

Yeast and its growth.—The yeast consists of a vast number of minute, oval plants, only visible with high powers of the microscope. Each of these is bag-like, contains a semi-fluid substance, and is called a cell. The yeast plant, when placed in a fluid containing sugar, grows rapidly, reproduces its kind, and thus gives rise to the action known as fermentation.

(See *Elementary Biology*, by Huxley and Martin.)

The potatoes contain a great deal of starch, and this is partially changed by the yeast into sugar, and by this means the yeast-plant has what it chiefly needs for its

growth. As yeast grows, it gives off a gas called carbonic acid. It is by the bubbles of this gas that the holes or spaces in the dough are formed.

Various kinds of ferment are employed, as, for instance, brewer's yeast or barm; and German yeast, which does not come up to the surface of beer as ours does, but settles to the bottom, and which is much used in making fancy breads, where the fermentation is required to be rapid. The gas may be formed in dough without fermentation, by adding carbonate of soda and an acid. 'Baking powders' act in this way. The taste of the bread thus made, however, is not very agreeable. In aërated bread, the lightness is produced by pumping carbonic acid into the dough. This is so perfected by Dr Dauglish's system, that the gas is forced through the whole dough in a few minutes. Alum is sometimes added in order to give whiteness to bread made from inferior flour. It is said to be an improvement in certain cases; but it can scarcely be wholesome, and is likely to produce indigestion.

New bread and stale bread.—Newly baked bread is softer than stale bread, and is often eaten in preference, although it is generally considered to be less digestible. After a day or two, new bread becomes more crumbly, and seems to be drier. It is not really drier, however; for if a stale loaf is covered with a closely fitting tin, and put into the oven and heated for an hour, it has, after cooling, all the qualities of new bread. Bread which can be easily compressed into balls between the finger and thumb, is scarcely fit to eat, because the saliva and the juices of the stomach have but little action upon it. For the same reason, buttered toast, muffins, crumpets, and the like are very trying to the stomach of a weak person.

(See *Foods*, by Dr E. Smith.)

Some strange substitutes for wheaten bread.—In Sweden and Norway, sawdust is sometimes made into bread. Beech, or some wood that does not contain turpentine, is soaked in water and boiled. It is then dried in an oven and ground, and is said in this state to have the smell and taste of corn-flour.

In times of famine, very good, wholesome white bread has been made in England from turnips.

In the siege of Paris in 1870, bread was made only one-eighth part of which consisted of wheat, the rest being potatoes, beans, peas, oats, rye, straw, husks of grains and the skins of vegetables, with water.

(See *Food and Dietetics*, by Dr Pavy.)

SALT.

Description:

1. *Composition.*—Common salt is composed of two elements—a choking gas called **chlorine**, and an inflammable metal called **sodium**. The compound therefore formed by the union of these two substances is called by chemists **chloride of sodium**, although the name by which most of us know it is common salt. From one of the two elementary substances forming salt—namely, from sodium—we obtain soda.

2. *Colour.*—When quite pure, rock-salt is colourless and transparent. A printed paper can be read through a block of such salt six inches in thickness. Generally, however, in large masses there is, besides flaws and stains, a pinkish or bluish tinge caused by the presence of other mineral matters. Indeed, salt has been found of almost every colour—red, brown, green, blue, gray, &c. Sea-salt is generally white, although it cannot be seen through. Good salt should at least be white and glistening.

3. *Structure.*—If salt dissolved in water is allowed slowly to become solid, it forms regular crystals of a cubical shape. Such crystals have been found on the bottom of the Dead Sea at a depth of more than a thousand feet. The crystals of manufactured salt have not this regular form.

Rock-salt is the name given to those masses of salt which are found in the earth in a solid form. The places where such salt is now dug out were once covered by a lake, or an estuary, or a part of the sea. The water slowly dried up, leaving behind solid blocks of salt. Such processes are going on at the present day in many parts of the world; especially is this the case with the Dead Sea and the Great Salt Lake of Utah. In the salt-mines of North-west India, vases and other ornaments have been cut out of rock-salt. In a large salt-mine in Poland—the Wieliczka mine—crucifixes, inkstands, and such like have been made by the workmen from the beautiful rock-salt. Two hundred years ago, in this same mine a chapel was cut out, having all its furniture, statues, decorations, and even doors, composed entirely of salt. The stalls and troughs for the horses too are generally cut out of the solid rock-salt, for it is found quite hard enough to stand the rough usage.

1. *Where found.*—Beds of rock-salt have been discovered in almost every part of the world. They are found at the sea-level, and at different heights above and below it. Thus some in Poland are 300 feet below the sea-level. One near Salzburg is 3300 feet above the sea, and another at Arbonne in Savoy is 7200 feet above the sea. The largest salt-mine in the world is that at Wieliczka. It has been worked for six hundred years, and is supposed to contain salt to last for centuries to come. In England there are large beds of rock-salt in Cheshire, and the mine at Northwich has been worked for two hundred years.

2. *Mining.*—Rock-salt is mined in much the same way

as coal is—that is, with pick, chisel, hammer, crowbar, gunpowder, &c. In some places, as at Cordova in Spain, where the salt forms a steep hill 500 feet high, it is quarried in the open. In other places it is dug out of pits. Several shafts lead down to the Wieliczka salt-mines; some for pumping up water, others for the use of workmen, horses, &c. Many of these shafts are in the form of spiral staircases.

The temperature of salt-mines is generally agreeable, and the air is dry and healthy. The chief danger to the miner comes from the occasional falling in of the roof of the tunnel.

3. *Preparation of table-salt, &c. from rock-salt.*—The pure crystal-salt which is obtained from certain mines is prepared for food by simply grinding it to powder. The ordinary rock-salt of many mines, however, such for instance as that obtained in Cheshire, is too impure for immediate use. Holes are therefore dug in the salt, and water is let into them and the salt dissolved. The brine thus formed is then pumped up and carried to large iron tanks or boilers which are 12 to 18 inches deep, and heated by furnaces. Here about half the water is boiled away, and the salt is scraped off. This salt is first drained, then dried in drying-houses, and finally ground for use.

Salt-springs.—Before the year 1670, when rock-salt was first found in Cheshire, all the common salt of England was manufactured either from the sea or from brine-springs. Most of the latter are in Cheshire, where some have been worked for nearly one thousand years. Shafts are sunk, and the brine is found sometimes, as at Nantwich, at 10 yards beneath the surface. At other places, as for instance Bampton, it is necessary to sink to a depth of 50 yards before reaching it. The brine is pumped up to the evaporating-pans by steam, and in these large open pans it is heated. **Stoved, common, large grained**, or **fishery salt**, may

be produced by certain differences in the boiling arrangements. The slower the evaporation, the larger the crystals. In all cases the brine is either actually boiled or kept hot for several hours, and the salt which is by this means deposited is raked up, drained, and dried.

Sea and lake salt:

1. *Salt of the sea.*—Sea-water is both salt and bitter. Several different substances are dissolved in it, but the most important is common salt. The amount of this varies in different seas. Where large rivers empty themselves into the sea, the water is rendered less salt for a great distance from the shore. In the neighbourhood of icebergs too, the sea is less salt, owing to the presence of melting ice, for ice contains no salt. The Mediterranean contains a little more salt than the ocean, because it is situated in warm latitudes, is not very deep, and is nearly cut off from the Atlantic. The Pacific Ocean is said to be less salt than the Atlantic.

2. *Salt lakes.*—One of the most remarkable salt lakes is the Dead Sea. The Great Salt Lake of Utah is another. There are some near the Caspian Sea and the Sea of Aral—both great salt lakes themselves; others are in Germany, South Africa, Persia, and the north of India.

Salt lakes may be divided into two classes:

(*a*) Those which owe their saltness to the evaporation of the fresh water which is poured into them by rivers. The Great Salt Lake of Utah is an example.

(For a description of this lake, see Geikie's *Text-book of Geology*, p. 395.)

(*b*) Those which were originally part of the sea. The lakes around the Caspian Sea are examples.

When more water is evaporated from a lake than is brought to it by rivers, that lake dwindles in size and becomes salter. In some of the shallow pools which border the Caspian Sea, salt is constantly being deposited and

forming a mass of rose-coloured crystals. Layers of salt are thus in some places gathering on the mud at the bottom, and the sounding line, when scarcely out of the water, is covered with salt crystals.

3. *Preparation of salt from salt water:*

(*a*) In warm climates the salt water is admitted into shallow trenches by the seaside. These cover a large extent. When a portion of the water has been evaporated, the liquor is removed by sluices from one trench to another, until at length the salt crystallises. In India, on the shores of some of the salt lakes, mud walls two or three feet high are made to inclose the brine as the water in the lake gets less. In these inclosed parts, when more evaporation has taken place and the salt has crystallised, it is easily got at. Men and women wade out ankle-deep in mud, and collect good-sized cakes of salt in their arms. These are brought ashore, and cast in heaps, where they soon fall to pieces. Each heap is weighed separately, and the labourers are paid according to the work they have done.

(*b*) In colder climates the salt water is evaporated in large boilers heated by fires, and the salt appears on the surface of the liquor as small crystals.

(*c*) It can also be prepared by repeated freezing of sea-water and removal of the ice, until at last a solution is obtained which, by a slight evaporation, yields a crop of salt.

Uses:

1. *For food.*—It is necessary for food, for it is found in the blood and in various fluids, such as perspiration, &c., which escape from the body. It causes an increased flow of saliva in the mouth, and so assists digestion. The worst suffering that could be invented for men would be to keep them without salt. The old laws of Holland ordained that criminals should be kept on bread alone, unmixed with salt,

as the severest punishment that could be inflicted upon them. Excess of salt is wrongly said to cause scurvy. Sailors suffer from this disease, not because of the salt provisions they eat, but owing to the deficiency of vegetables and fruits.

The amount of salt required varies with the kind of food we eat; but it should be generally about half an ounce each a day. For cattle, too, salt is necessary. In a wild state, cattle, horses, deer, &c. are so fond of salt, that they will make long journeys in search of it. In the backwoods of America there have been found tracks of animals, like broad beaten highways, leading to salt-springs, or 'salt-licks,' as they are there called.

2. *For preserving food.*—Fish and meat are easily preserved by salt. Meat taken into salt-mines remains sound and good for a long time, being preserved by the salt atmosphere. It is said that dead horses which have been thrown into the abandoned workings of the Wieliczka mines have been found years afterwards quite preserved by the surrounding salt.

3. *For agriculture.*—Too much salt in soil is a cause of barrenness; but on the other hand, deficiency of salt hinders the proper growth of most food-grains. Salt has therefore to be added in such cases. It has been found that sprigs of plants live longer in slightly salt water than they do in water perfectly pure.

4. *For manufactures.*—Salt forms a glaze for that variety of pottery called stoneware, by being thrown into the oven where the pottery is baked. It is used in very large quantities for the manufacture of carbonate of soda and caustic soda, chlorine compounds; and to a less extent in the reduction of metals and some minor chemical industries.

(For further information about common salt, see *Text-book of Common Salt*, by J. J. L. Ratton.)

SUGAR.

Varieties of sugar.—Two chief—namely: 1. Cane or crystalline sugar; 2. Grape-sugar.

Cane-sugar is obtained from the sugar-cane chiefly; but also from the maple-tree, palms, and beetroot.

Grape-sugar is contained in grapes and other kinds of fruits. It is not so sweet as cane-sugar, nor so easily dissolved.

The Sugar-cane:

1. *Where grown.*—In hot or tropical countries, as the southern part of the United States, West Indies, Spain, Mauritius, Java, Brazil, parts of Africa, Australia, East Indies, and over a great part of Asia, from which continent it was introduced into Cyprus. It was brought to England about the fourteenth century, and as it was imported from a very great distance, it was very expensive.

2. *Description.*—The cane grows to a height of 12 or even 20 feet, and is from 1 to 2 inches in thickness. The root is jointed, and sends up several smooth, jointed, unbranched stems. The leaves are long and narrow, and are wrapped round the stem for some distance like the leaves of our grasses. At the tip of the stem is a bundle of downy flowers of a pale lilac colour. A field of canes fully grown and in flower has therefore a handsome appearance. Every season, for several years, after the sugar-cane has been cut down, fresh canes continue to spring from the roots. After this no longer takes place, new canes may be produced by planting the top joints when the cane is cut.

Preparation of sugar from the cane:

1. When the canes are ripe, they are cut close to the

ground with a large knife. The leaves and tops are then chopped off and left in the field—the rest being taken to the mill. Here the canes are passed through heavy iron rollers, and the juice is pressed out and run into large vessels.

2. In these vessels, a little quicklime is added to the juice, which is then passed through a series of evaporating-pans, where it is heated more and more until it boils furiously. The impurities rise as a scum, and are removed, and the liquor gets about as thick as oil.

3. It is now taken to the coolers, wooden vessels in which the crystals of sugar separate from the liquid, and the latter is drained off. The crystallised part is **raw sugar**, and is packed in hogsheads for sale. The liquor which drains off is **molasses**.

Refining.—The crystals of sugar are of themselves colourless; but in raw sugar they are tinged by a dark syrup, which has to be got rid of. This may be done either by

(*a*) Placing a moist layer of clay over the sugar, so that the water from the clay may pass slowly through the sugar, and carry away the syrup without dissolving much of the crystals; or by

(*b*) Placing the raw sugar in a cylinder covered with thin wire gauze. This cylinder being made to turn round and round at a high speed, the syrup is thrown off through the gauze, and the sugar is left behind.

Raw sugar is changed from moist or brown into white or loaf sugar by dissolving and then boiling with bullock's blood. This causes the impurities to rise to the surface, from which they are skimmed off. The clarified syrup is next filtered through animal charcoal, and thus rendered nearly colourless. It is still further concentrated by boiling it in vacuum pans, and it is finally poured into conical

moulds, where it solidifies into loaves. The liquid part, which is allowed to run off, is **treacle**.

Good sugar should be—

1. Composed of large crystals, and, if lump sugar, should be of a pure white colour.
2. Free from any unpleasant smell.
3. In the case of raw sugar, not too moist when rubbed between the finger and thumb.
4. In the case of lump sugar, not too easily broken.

Cane-sugar has been found to be adulterated occasionally with starch, sand, and water. Iron is sometimes found in inferior sugars, and has the effect of making the tea to which such sugar is added, black.

Uses of sugar.—As an article of food, it is of great value in supplying to the body what it loses by muscular contraction, and it also aids in the formation of fat. Negroes who work in sugar plantations become fatter during the season for gathering in the sugar-cane, the months of March, April, and May, owing to their habit of constantly chewing pieces of the cane while they are working. Sugar is also useful for preserving fruits and other vegetable products. There is no reason for supposing that it injures the teeth.

WOOLLEN CLOTH.

Washing and shearing.—Wool, before being removed from the sheep's back, is cleansed as much as possible by washing. This is done either in the old-fashioned way by driving the animals into a pond, and scrubbing them, or by an arrangement which takes a good deal less time, and does the work more thoroughly. The sheep are made to go into a bath, from which the only outlet leads into pens. While imprisoned in these pens, numerous

jets of water are driven with force upon the wool. In this way the dirt is quickly removed; more especially as hot and cold water are both used. The sheep are now shorn, either by shears or by mechanical cutters acting on the principle of shears.

Sorting or Stapling.—The first person to whom the fleece passes, after its removal from the animal, is the **stapler** or **sorter**. He picks to pieces each fleece, and arranges the locks of it into separate heaps. A fleece generally furnishes eight or ten different qualities, according to the part of the animal's body from which the wool has come.

Scouring.—However carefully the wool may have been washed, when on the sheep's back, it is not yet clean enough. It has to be **scoured.** For this purpose it is placed in a long trough containing warm soapy water, which removes grease. It is then passed between two rollers and squeezed nearly dry. After being washed in clean cold water, to get rid of soap, it is carefully dried.

Willowing.—When quite dry, the wool passes to the **willowing-machine**, where its locks are disentangled, and all the dust fanned out.

Some wool has in it seeds of plants, which the sheep has picked up while grazing. These are called **burrs**, and are very troublesome to get rid of. The worst wool of this kind is that from Buenos Ayres, in South America.

Oiling.—The washing which the wool has undergone by this time has made it dry and harsh. It has therefore to be slightly moistened with a thin clear oil, and this is done by a machine, which causes a fine and almost invisible spray to play upon the wool.

Carding.—In this process the fibres of the wool are, as it were, combed out by steel points placed on rollers, which are kept rapidly turning. These rollers are so thickly covered with projecting pieces of steel wire, that they form, so to speak, cylindrical brushes. Carding is a peculiar operation by which the fibres are equalised and made free from 'nibs' or 'moats,' or anything which would produce uneven yarn. The teeth or points of one roller work very close to, but do not touch, those on the one it works against, so that the wool is carded out into a broad thin sheet or lap.

Attached to the carding-engine is a condenser for dividing the carded lap of wool into strips, and rolling them into slivers or slubbings—the first form of the yarn.

Spinning consists in twisting the fibres into threads. In earlier times this was done by hand, two instruments being used. One, called the **distaff**, was a stick with a knob at the end. The other, the **spindle**, was a much shorter rod, with a notch at one end and a weight at the other, to enable the spinner to keep it turning round. The fibres of the material to be spun were loosely twisted around the distaff, which was then put under the left arm. A few fibres were next pulled out by the right hand and twisted into a thread. This thread was wound upon the spindle, being secured by the notch. The spindle was then kept revolving by the right hand, so as to continue twisting the thread already begun. When enough thread was spun to permit the spindle hanging from it to reach the ground, the thread was removed from the notch, and wound on the spindle. Then a new length was commenced.

This method of spinning gave place in time to that of the spinning-wheel, and both have gone out of use by the introduction of the spinning-machine.

The spinning-machine now in general use is called a

mule. It consists of a fixed and a movable part. Upon the former are placed the bobbins, with condensed sliver from the carding-engine, and the drawing-out rollers. The movable frame carrying the **spindles**, runs out to a certain distance, stretching the **fibres**, and twisting them. It then returns, and the **yarn** or thread which has been thus formed is wound upon small bobbins.

Weaving.—This consists in making the yarn into cloth. The rudest barbarians cross grass and such substances, and thus weave mats, bits of garments, and the like. In a piece of cloth the threads are crossed; there are two sets—namely:

(1) Those running lengthwise, from end to end of the piece, and called the **warp**.

(2) Those which cross the warp threads, and are called the **weft** or **woof**.

The weft thread is carried across the others by a sort of reel pointed at each end, and called a **shuttle**. Instead of putting this shuttle under and over each long thread, one at a time, every alternate thread of the warp is raised, and the shuttle is passed underneath. While passing *under* these threads, it goes *over* the rest. When this has been done, the threads which were before raised are lowered, and the others are raised. The shuttle is then brought back over the threads it went under before.

The warp threads are generally sized with a glutinous solution in order to prevent their chafing, and also to give them strength to bear the strain.

Weaving takes place upon a **loom**, which is a frame for stretching out the warp or web. This web is kept stretched between two beams. Upon one of these beams the yarn is rolled, and upon the other the cloth is wound as it is woven. Weaving is nowadays done chiefly by steam-driven looms.

Picking.—The cloth as it comes from the loom has a very coarse appearance, and if held up to the light, shows many small spaces, where the threads cross. This 'fuzzy' appearance, as it is called, is got rid of by stretching the cloth on a frame and picking out every nib and other imperfection.

Washing.—The cloth is next washed in a mixture of salt, blood, water, and some other substances. If this is carefully done, the oil, sizing, and dust are got rid of, and the cloth has an elastic touch.

Dyeing.—If the wool was not dyed, as it sometimes is, before carding, this must now be done. The cloth is then washed and passed on to the

Fulling mill, where it is beaten with pestles or stocks, as it lies in a trough of thick warm soap-suds. Sometimes, instead of being beaten in this way, the cloth, while still saturated with suds, is passed through a milling-machine, which subjects it to great pressure. This brings the fibres of the cloth so close together, that the teeth-like scales, which are to be found on every fibre of wool, interlock with one another. Thus the cloth becomes so compact as to show scarcely any signs of being woven. After another washing, it is passed to the machine by which the nap is raised.

Teasling.—There is a plant, something like the thistle, and called the teasel. When the flower-head, which is shaped something like a fir cone, is ripe, it is covered with projecting hooks or scales, all of which are curved in the same direction. These scales are used for raising the nap on woollen cloth. They are arranged in frames, and over them the cloth is passed. The hooks thus catch some of the woolly fibre, and drawing it out, give the cloth a hairy appearance. This plant has, for

many years, therefore, been cultivated for the purpose of raising the nap of cloth. No arrangement of steel or other points does so well as the spines of this plant, for they do *not* tear or destroy the cloth. The spines themselves give way if the threads resist.

Shearing.—The nap raised by the teasles is, in all fine and most common cloths, shorn or cropped off to a uniform level by a cutting machine, which has a roller with spiral steel blades acting against a fixed straight blade.

Lustring.—To produce a lustre which is not spotted by rain, the cloth is first wound on an iron roller. This must be done quite smoothly, because any wrinkles there may be will remain and spoil the surface. The roller and cloth are then placed in hot water (160°-180° F.), and kept there for six or eight hours. They are then taken out, and the cloth is allowed to dry on the roller. This is repeated seven or eight times, and lasts a fortnight. The cloth is afterwards pressed with hot iron plates between each folded pile of fifty yards or so.

[The above operations are for the manufacture of woollen cloth; but the processes employed for the manufacture of worsted cloth, in its many varieties, although made of the same animal fibre, are in the main quite different.]

The manufacture of woollen cloth is a very ancient one.—In Lev. xiii. mention is made of garments having 'the warp and woof of linen or of woollen.' The Phœnicians were manufacturers of wool, and celebrated in the art of dyeing it. Among the Greeks and early Romans, not only weaving, but the whole process of preparing the yarn, was carried on in every house of any size. Woollen garments were usually worn by Romans of both sexes. These people were the first to manufacture wool in Britain, at Winchester, and the wool was celebrated far and

wide for the fineness of the thread. Later on, the mother of Alfred the Great was famed for her skill in spinning wool, and taught her daughters the same art. For a long while the people of Flanders excelled in the manufacture of wool, and by them both the English and the French were instructed. Many Flemish settlers came to this country in the reign of William I. and in that of Edward III.

COTTON.

General:

1. *Where grown.*—Principally in the United States; West Indies; Brazil, Guiana, and other countries of South America; Egypt, India, China, and the island of Bourbon.

2. *Description.*—Cotton is the soft, white, hairy covering of the seeds of several distinct but closely allied species of plants, which are believed not to exceed seven in number. These are popularly called cotton plants. The flowers, and even the leaves of the common mallow, found abundantly in Britain, are not unlike those of the cotton plants, and botanically the mallow belongs to the same natural order.

One species of cotton plant growing in India and China is tree-like, being from 15 to 20 feet high; others are shrubby, and others again are herbaceous. The North American species, including the far-famed sea-island cotton, which has long silky hairs, are herbaceous. The tree-cotton has a reddish-purple flower, but most of the other species have yellow flowers. The finest sea-island cotton is grown on islands on the coast of Florida and Georgia, and on the mainland of Florida; but this kind is now grown in other parts of the world as well.

In the case of herbaceous cotton, which includes the kinds most generally cultivated, seeds are sown in spring,

and the plant appears above ground about eight days afterwards. The rows of young plants are then carefully hoed and weeded. The flowers come and fall off, leaving behind the pods or seed-cases. Now is the time to watch for the approach of the cotton-worm, which will devour the cotton, and so destroy whole crops as to make them look as if burned up by lightning.

When the pod is ripe, it bursts, and the cotton protrudes. It is then collected by picking with the fingers. Each person is expected to pick two or three hundred pounds of cotton every day. At first it is dried in the sun, and then ginned.

Ginning.—After picking, the seeds still cling to the cotton, and they must be got rid of. This is done by a machine called the **cotton-gin**.

1. The simplest form of this is the one in use in India. It consists of two rollers of hard wood, between which the cotton is drawn, and the seeds forced out in the process. This operation is, however, very slow and laborious.

2. The **saw-gin** is a contrivance in which a series of saws turns round between bars or gratings, upon which the cotton rests. The teeth of the saws catch the cotton and drag it through, leaving the seeds behind. Underneath the saws, a set of stiff brushes is made to turn round. These sweep the saws clean. Although by the saw-gin the cotton is separated from the seed more rapidly than can be done by the simple gin in use in India, yet by the former the fibres are to some extent injured by the action of the teeth.

After the cotton leaves the gin, it is placed under powerful presses, packed into bales, and shipped to this country.

Opening and scutching.—When the bales reach the factories where cotton is made into calico, the cotton from several bales is emptied and thoroughly mixed

together. A machine then breaks up any hard lumps there may be. By this machine, too, the cotton is further beaten and fanned. This makes it looser, more fleecy, and easier to work. It needs all this, because it has been so tightly pressed together. Some Indian cotton is found, when opened, to be sticking together in cakes, as if glued, requiring to be steamed before it can be loosened. The next process is to form the cotton into a continuous ribbon, with the fibres more or less parallel.

Carding.—All this time the cotton is matted together, the fibres lying across one another in different directions. They could not be spun while in this condition. The cotton is therefore taken to the carding-machine, which combs the fibres out straight. And as the cotton is naturally curly, several brushings and combings are required. In this way not only are the fibres placed straight, but the short ones are at the same time removed. The cotton leaves the carding-machine in the form of a narrow ribbon called a **card-end** or **sliver**, which is either coiled up in a tin can, or is wound upon a large bobbin.

Drawing.—Even after carding, the fibres of the cotton are not straight enough. The card-ends or slivers are therefore passed to the drawing-machine. Here several are stretched and drawn out through successive pairs of rollers, until they together form a sliver or end no thicker than one was at first.

Spinning.—After one or two intermediate processes, the cotton fibres are spun into yarn. In spinning operations, there are two kinds of machines in general use—namely, **throstles** and **mules**. The yarn spun by the throstle has a closer fibre, and is stronger and more even than that spun upon the mule. The mule has the spindles placed in a carriage moving backwards and forwards upon iron rails.

The carriage moves forwards, drawing out and twisting the threads as it does so, until it reaches the end of its course. The cotton is thus stretched as much as it will bear. The carriage is stopped, the spindles still turning round, however, and twisting the thread; then it is drawn back again, winding up the yarn all the time.

Weaving is very much like the weaving of woollen thread into cloth, which has been already described.

LINEN.

Flax is the plant from which linen is made.

1. *Description.*—This plant has a slender green stem, about two feet high, surmounted by bright blue flowers. When these fade and fall off, there are left behind rough capsules, or seed-cases, each containing ten flat brown seeds. Flax seed or linseed is sometimes used for feeding cattle, and a valuable oil is obtained from it.

2. *Where grown.*—Russia produces more than one half of the flax of commerce; but it is also largely grown in Germany, and to some extent in most other European countries, the finest quality being obtained from Belgium. A good deal is grown in Ireland. The mummies of ancient Egypt are wrapped in linen, and considerable quantities of flax are still grown in that country.

3. *Kind of soil required.*—Flax will thrive on several descriptions of soil, but a dry loam is perhaps the best kind. If the farmer desires to grow the flax for the sake of its seed, he will sow it thinner than if his chief care is to produce excellent fibre in the stem. When the plant has reached the height of three to five inches, it must be carefully freed from weeds.

Pulling and rippling.—When the stalk is turning

yellow, and while the seed-vessel is changing from green to brown, the plant is pulled. A fine day is generally chosen for this work. The handfuls of pulled flax are then laid across each other. While in the field, the seed-cases are removed from the stalks in the following way. An instrument called a **ripple**, something like a large comb, is screwed on to a plank. Through this comb, a man, who sits astride of the plank, draws the flax, and the bolls or seed-vessels are thus pulled off.

Steeping or retting.—The flax is put, root downwards, in a pool of pure soft water, and left to remain for ten days or a fortnight. It is kept under by a layer of rushes, on which turf or straw is placed, with some stones above. As soon as it is found that the woody core of the stem separates easily from the fibres, it is known that the gummy parts have been dissolved out, and the flax is therefore ready to be removed from the water.

Grassing.—The flax, after being taken out of the water, is spread out evenly and thinly upon the grass in the sunshine. It is turned over after a few days' exposure, and then left for a week or so longer before lifting.

Lifting.—In doing this, the lengths have to be kept straight, and the ends even. The flax is then allowed to dry for a few hours, after which it is tied up in small bundles, and stacked like grain.

Breaking and scutching.—The flax is next threshed with a wooden mallet, first on one side, and then on the other. Sometimes, instead of this, it is passed between two grooved rollers. In either case, the woody central part of the stem is broken. The flax is then hung up, and struck with the blade of a scutching knife until the fibre is quite cleaned from the woody core.

Heckling.—In this process, the flax is split up into its

finest fibres, and these are made to lie straight. For this purpose, the flax is drawn through a sort of brush called a **heckle**, formed of strong sharply pointed steel needles instead of bristles. In the case of hand heckling, the heckle is fastened on to the table in front of the worker, but more usually it is done by a machine on which there is a series of heckles. By heckling, the fibre of the flax is separated into two kinds—namely, the **line**, which remains in the hand of the heckler; and the **tow**, which is left on the teeth of the instrument. The line consists of long, fine, gray, glistening fibres, which look almost like silk. Tow consists of short ravelled fibres.

Drawing.—The flax 'line' is next passed through gills or small heckles. As the rollers which draw it through these gills move faster than the rollers which feed them, a thin ribbon-like 'sliver' is formed. A number, say eight, of these slivers are now made to converge, and are drawn out by a similar arrangement of rollers through gills again to such a degree of thinness that the resulting single sliver is less than one of the eight.

Spinning.—Flax is spun into yarn in much the same way as cotton, on the machine called the throstle. The fibres are moistened with warm water during the operation, as it is found that the thread formed is finer and smoother than when the yarn is spun dry, which is sometimes done for the coarser kinds.

Reeling.—After the yarn is spun, it is unwound from the bobbin, and measured on reels. The quantity is expressed in **leas**, **hanks**, and **bundles**. A lea is 300 yards. A hank is 10 leas or 3000 yards. Twenty hanks or 60,000 yards make one bundle.

Before this yarn can be woven into linen cloth, it has to go through several processes. The harder and more twisted

threads are arranged evenly, side by side, to form the warp. They are then **sized** with a paste of fine flour, to which a little salt has been added. After sizing, which makes the threads smoother and stronger, the warp is wound round the **warp-beam**, or, as it is called, the **weaver's beam**.

Bleaching.—Linen cloth, when woven, has a brown colour, and therefore needs to be whitened. For this purpose, it has to pass through several processes. It is washed, boiled in lime-water, then placed in a sour liquid, washed again, boiled with resin and soda ash, washed a third time, and steeped in water containing bleaching-powder, or chloride of lime. Some of these operations are repeated several times, and for hours together. If the linen is to be dyed, it is now, after a final wash, removed to the dye-works. Before leaving the latter place, the linen is washed, and rinsed, and then passed to the starcher.

Starching.—A roller dips into a trough of starch, and lays it evenly upon the cloth. Another roller next squeezes the linen, which is then dried in a steam-heated room in fifteen minutes. Starching improves the appearance of the linen, and makes it seem stronger and thicker.

Calendering.—A machine provided with revolving brushes first sprinkles the cloth lightly with water. The cloth is next passed under heavy rollers of wood, iron, and pasteboard, and comes out with a soft silky gloss, and is ready for making up. It is folded and ornamented according to the style of the particular market to which it is going. It is then placed in a powerful press with a sheet of pasteboard between the pieces.

After being thus flattened, the linen is packed in boxes. nailed down, and corded.

SILK.

The **Silkworm** is really a caterpillar.

1. *Eggs.*—In summer the silkworm moth lays the eggs from which the silkworms spring. These eggs are about the size of mustard seed, and at first of a yellow colour. They may be collected and preserved during the winter and spring, until the food on which the caterpillars are to live is ripe.

2. *Hatching and rearing.*—When required, the eggs may be hatched by gradual heat. The newly hatched silkworms are at first covered with sheets of perforated paper, on which leaves of the mulberry tree have been spread. These leaves soon become covered with the worms, and are then removed to shelves of wicker-work, covered with brown paper. Here constant supplies of fresh leaves are brought to the rapidly growing animals.

3. *Moulting.*—As the silkworm eats greedily, and grows very quickly, it casts its skin four or five times. The whole covering of the animal is thrown off, even including that from the jaws and teeth.

The creature has six scaly legs in front, and ten softer ones behind. The mouth is very large, and below the jaw there are two orifices, from which the silk comes as a sticky juice, which hardens in the air.

4. *Spinning.*—When about to spin, the silkworm usually selects some corner in which to begin. It moves its head about in various directions, and fixes the thread at different points, winding the silk completely round its body. This takes about four or five days. The case which is thus spun round the animal's body is called a **cocoon.**

5. *Change into moth.*—The silkworm remains quite still,

covered up in this way, for about twenty days or longer. It then breaks through the cocoon, and escapes as a moth of a pale cream colour, with wings which are only used to flap the air, without giving the insect the power to fly. It lays two hundred to five hundred eggs in a short time, and then dies.

6. *Varieties.*—There are two useful kinds of silkworms:

(*a*) The common silkworm of France, Italy, India, China, and Japan, which feeds on mulberry leaves, and furnishes by far the larger quantity of the silk of commerce.

(*b*) The Tussah worm, which feeds upon certain descriptions of oak, castor-oil plant, and some other trees and shrubs, and is found in China and India.

Stifling.—Only a certain number of the silkworms are allowed to change into moths and escape from the cocoon, for the sake of the eggs they afterwards lay. The other silkworms are destroyed while still in the cocoon. This is done by the action of steam, which, while it passes through the silk without injuring it, kills the animal inside, to prevent its cutting a hole in the cocoon and spoiling the silk.

Reeling.—The cocoon, which consists of one long unbroken filament, must now be unwound. For this purpose, after the outside **floss** has been removed, the cocoons are placed in a basin of hot water, which soon dissolves the gummy parts, and the end is found. The ends of perhaps six cocoons are first taken and wound off on to the reel as one thread. The silk fibre gets thinner as the centre of the cocoon is approached. For this reason, the reeler, in order to keep the thread which is being formed, of one thickness throughout, must now add a certain number of cocoons. Thus, suppose he starts with six, he will very likely

find it necessary, as his work proceeds, to increase the number to nine, so that the thread may be, at the finish, of the same thickness as at the commencement. The silk which is thus reeled is **raw silk.**

Winding and cleaning.—The raw silk is next wound upon bobbins, and it is cleaned by making it pass, as it is transferred from one bobbin to another, between two parallel plates placed so close together that any knot or irregularity upon the silk is caught. Even slight differences in the thickness of the thread stop the motion.

Twisting and retwisting.—Reeled threads of raw silk are not twisted at all, and are called **singles**. Such silk is not dyed before it is made up. Bandanas, Pongees, and such soft silk cloths, are manufactured of singles. But nearly the whole of the silk fabrics made in Europe are woven of thicker threads than raw silks furnish. The latter are consequently doubled and twisted on suitable machines. Raw silks cannot be dyed in the thread, because for want of a twist the filaments would separate in the dye bath. According to the kind of twist which is given, either **tram** or **organzine** is formed. When two or more single threads without twist are united, and then twisted together, tram is formed. It is chiefly used for the weft or cross thread. If two or more single threads are separately twisted, and then united and retwisted in opposite directions, organzine is formed. This is used for the warp thread. **Floss** silk consists of short broken filaments, which are carded and spun like cotton.

Boiling and dyeing.—In order to get rid of the gum as well as the colour which the silk has from the worm, hanks of silk are placed over long sticks, and allowed to dip into boiling water, containing soap and carbonate of soda. After being taken out of this, the silk is washed in cold water, and

then passed on to the dyeing tanks. Here the hanks of silk are hung upon sticks again, and about two-thirds of their length permitted to dip into the dye. After a time, they are pulled over the sticks, so as to bring the other part of each hank into the dyeing solution. Silk is bleached white by the sulphurous acid gas obtained by burning sulphur. It is dyed crimson by cochineal, pink by safflower, blue by indigo, yellow by various vegetable dyes, green by indigo and fustic, and black by logwood and copperas (a salt of iron). Red, blue, lavender, and other colours are now obtained from the aniline or so-called coal-tar dyes.

Chief kinds of silk fabrics.—These are very numerous, so that only a few can be mentioned here.

1. *Plain silks* made in large quantities for dresses and other purposes.

2. *Satin.*—In weaving this, instead of raising every other thread of the warp, and passing the weft under all these, the weft thread is carried under five or six neighbouring threads of the warp, then over one, again under five, and so on. In this way, the weft is almost hidden under the warp, the threads of which show a rich, glossy surface.

3. *Velvet.*—The nap or pile is formed of part of the threads of the warp, which are woven on a long, needle-like wire with a groove along it. These warp threads are then cut by passing a sharp knife along the groove of the needle to the ends of the warp. The cut ends, when brushed up, form the velveting.

4. *Crape* is a silk gauze woven with yarn containing a good deal of the natural gum of the fibre. The process by which the crimpy appearance is given to it is kept secret, but it is understood to be done by wooden rollers, with a pattern sunk upon them.

5. *Figured silks* woven with various patterns on a

peculiar kind of loom; also used for dresses, but more largely for covering furniture, for curtains, &c.

History of silk manufacture.—The cultivation of the silkworm was known to the Chinese at least 2600 B.C., and was introduced into Japan in the early part of the third century of the Christian era.

In 400 A.D., the manufacture of silk was largely carried on in India. In the sixth century, both the rearing of the worm and the manufacture were established in Persia; and in the same century, they were introduced into Europe direct from China. The industry soon became important in Greece, from which it extended to Sicily and Italy. In the sixteenth century, eggs of the silkworm were largely introduced into France; and Lyons, with its neighbourhood, soon became famous.

Silk manufacture in England dates from 1585, when the sack of Antwerp caused many Flemish weavers to come to this country. About a hundred years afterwards, a large number of French weavers settled in Spitalfields in London.

The silk trade in this country is now carried on principally at Manchester, Macclesfield, Glasgow, Coventry, Nottingham, Derby, Dublin, and Spitalfields.

LEATHER.

Difference between skins and leather.—Skins of animals in their fresh state are flexible and soft, but become hard and horny when dry. If kept moist they soon rot, unless something is done to preserve them. It is necessary therefore to submit them to some treatment which will make them permanently soft and pliable, as well as keep them from decay. The usual way of doing this

is by **tanning** them; and the skin, when tanned, is called **leather**.

Varieties of hides and skins.—Hides are **thick** skins. The most valuable ox-hides come from South America, from the Cape of Good Hope, and Morocco. Horse-hides are not so fine in the grain as those of the ox; and they are generally used for saddlery and thongs for whips. Sheep-skins, for miscellaneous purposes, are most useful, and are made into wash-leather, parchment, driving-gloves, &c. The skins of lambs in Italy, France, and Spain are often used for making gloves. Goat-skins are sent to this country from Switzerland to be prepared into true morocco leather, which is largely employed for covering chairs, carriages, and books.

Kids are reared with great care in France and Switzerland. They are generally killed as soon as they leave off taking the mother's milk, for it is thought that the skin becomes coarser when the animal commences feeding on herbage. Deer-skins are collected in large quantities in Canada and the United States, and are imported into this country for the manufacture of braces, boots, gloves, and the like. Pig-skin is valuable to saddlers. It is largely obtained from Scotland, where pork is not, as it is in England, cooked with the skin on. Cat, dog, and rat skins make into leather well suited for glove-making. Excellent leather is made from the skin of the seal. The fur called sealskin is obtained from otaries, a peculiar kind of seal found off the north-west coast of America.

Cleansing the hide:

1. *Steeping.*—This is to get rid of blood or dirt as well as the salt with which the hides from abroad have been preserved. It takes about eight or ten days with foreign hides. They are washed and soaked in water, being taken out and drained twice a day.

2. *Dressing.*—The flesh side of the hide is first planed with a knife to remove fatty tissue and other matters from the skin. Then the hides are passed through fulling-mills, and beaten with heavy hammers to render them supple. A second steeping and dressing of the flesh side follows.

3. *Liming and sweating.*—The hides are commonly placed in pits containing lime, but in the case of thick hides for soles, they are rubbed with salt or vinegar, and then put, flesh side to flesh side, in an air-tight tank till a partial putrefaction is accomplished. The latter process is called sweating. By either treatment the hair is so loosened that it is afterwards completely scraped off.

4. *Raising the hide.*—This is to remove the lime and also to open the pores in the skin, so that the tanning materials may more easily soak in. The hide is put into a sour bath of refuse barley, rye, malt, or bran. After being in this liquor, the hide becomes distended to twice its former thickness.

Tanning.—The hides have now to be placed under the influence of **tannin** or **tannic acid**. Excepting the nerves and blood-vessels, skin has a composition identical with that of gelatin, and it is only upon this part that the tanning processes are exerted. The object of these processes is to get the skin thoroughly impregnated with infusion of oak bark, or other astringent vegetable matter known as tannin. The materials which can be used in tanning are numerous. Besides that of the oak, the barks of the larch, willow, and other trees, acorn cups, the leaves of some plants, and the dried juice of others, are all more or less employed. Barks are cut or ground up before an infusion of them is made. It would not do to put the hides in strong tan at first, for the outside of the hide would become so hard as to prevent the tan from acting

on the inside. Accordingly, hides are first placed in pits containing a weak mixture of tan and water, called **ooze**. From this they are transferred to slightly stronger solutions every day for about six weeks. This having been done, the hides are next placed in great tanks, on the bottom of which is a layer of tan which has been already used. Above this is a layer of fresh oak bark, then layers of hides with layers of bark between them, until the top is reached. Over all there is a covering of spent bark. Water is finally poured on until the topmost hide is covered. Here the hides are allowed to remain for eight or ten weeks. They are then moved to another tank, to stay for three or four months. Out of this they are once more removed to a third tank, in which they lie for five months or more. Thus about a year is required to tan the heavy hides which form sole leather. Thin skins, on the other hand, may be tanned in seven or eight weeks. When completely tanned, the leather is dried, beaten, and rolled with a brass roller. By this time it has become solid and pliant.

Currying.—The object of currying is the conversion of rough leather from the tan-pit into a smooth, soft, and pliable skin. The processes are numerous and complicated, and vary with the kind of leather required, so that we can only mention one or two of them here. The leather is first soaked in water and stretched. What was the flesh side is next shaved with a sharp knife. If a polished surface is to be produced, the leather, besides being otherwise manipulated, is rubbed with pumice-stone, then with cork, and finally with metal and glass 'slickers.' Thus the surface of the leather is freed from all inequalities. In order to make it more supple, it is covered with a mixture of cod-fish oil and tallow while still wet, and is then hung up to dry. After further treatment, leather for the uppers

of boots and shoes is finally dressed with a paste of fish oil, tallow, lampblack, wax, soap, and copperas. This prevents it from being injured by the strong acid which blacking generally contains.

COAL.

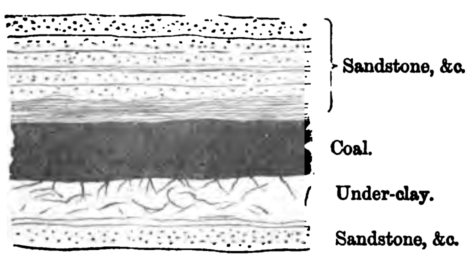
What it is.—Compact, brittle rock; generally of a deep black colour, although sometimes brown. At the end of a piece of coal it may be seen to be made up of layers. Coal splits most easily in the direction of these layers.

Slices of coal have been cut and rubbed so thin as to be transparent. Under the microscope, such sections have been seen to contain seed-vessels of club mosses, which were tree-like in size, and of ferns.

Chemists have analysed coal, and found that it consists of the same elements or constituents as wood or peat, but in different proportions.

Coal is therefore really the remains of plants which have been pressed together and changed.

How coal was formed.—Coal is found to lie in beds, sometimes only a few inches in thickness, at other times as much as seven or eight feet thick, and occasionally much thicker. Usually these beds or seams occur in the way shown in the accompanying figure. The under-clay contains branching masses like roots, and is really the soil in which the vegetation, which now forms the coal, once grew.



The places where this vegetation flourished and decayed were only a little above the sea-level. After the dead and fallen plants had formed a great thickness, the land must have sunk slowly beneath the water. Then sand, mud, shells, &c. were deposited. By-and-by, the land was again raised above the surface of the water, and in time plants once more grew upon it. This land in turn sank, and upon it were deposited sand, &c. as before. By the pressure of the mass of rock above it, and by the action of the water, together with other agencies, such as the increased temperature caused by the pressure, the vegetable matter became changed into coal.

We know that the land must have been thus raised and lowered, because we find the beds of coal separated by rocks containing shells and other remains of sea and fresh-water animals.

Where found:

1. **In British Islands**—*In Scotland.*—The most northerly coal-field, which, however, is only occasionally worked, is at Brora, in Sutherlandshire. The great coal-fields of Scotland are found in a belt of country thirty miles wide, extending from the shores of Fife and Haddington to the coast of Ayrshire.

In England.—Nearly all the coal-fields lie north and west of a line drawn from Bath to Hull. The chief are in Northumberland and Durham, Yorkshire, Lancashire and Cheshire, North Wales, Staffordshire, and South Wales.

In Ireland.—Leinster, Tyrone, and Antrim are the principal localities; but the total quantity of unworked available coal in the country is said to be little more than the amount raised in Great Britain in a single year.

2. **Abroad**—*In Europe.*—France produces insufficient to supply her own needs. Belgium, for her size, has a greater

store of coal than any other country in Continental Europe. Important coal-fields occur here and there in North Germany. Austria is not particularly rich in coal. Spain includes some valuable seams, but they are not much worked. Italy has some coal in Piedmont and in Sardinia. Some valuable fields have been found in Sweden. In Russia, the most promising coal-field is one stretching along the Sea of Azov for 180 miles.

In Asia.—Coal-fields are worked in India, in Borneo, in Japan, and in the northern provinces of China.

In Australia.—Those of New South Wales, Victoria, Tasmania, and New Zealand are each becoming famous.

In Africa.—Coal deposits were discovered along the banks of the Zambesi by Dr Livingstone.

In United States.—New England, Pennsylvania, the Michigan basin, the Appalachian basin, Illinois basin, Missouri basin, and Texas basin. The coal-fields of these states are of vastly greater size than those of the United Kingdom.

In Canada.—Newfoundland, New Brunswick, and Nova Scotia.

In South America.—Coal is worked in Brazil, Chili, and Peru.

How obtained.—Sometimes from the sides of hills by level workings or by inclines, but generally by pits. At least two shafts are sunk to each mine. Some shafts are between 300 and 400 fathoms deep. From the shaft, broad passages are made into the coal. Out of these, narrower ones are made to branch. Thus the miners are at work at the coal at many points at once. As soon as hewn down, the coal is put in a truck and conveyed to the bottom of the shaft, from whence it is raised on a cage by a steam-engine to the top.

1. *Ventilation.*—As explosive gases and also stifling gases

are often found in mines in large quantities, it is necessary that the mine should be well ventilated. This is, in some cases, secured by a furnace in one shaft. The heated air of this shaft ascends, and to supply the place of this, air descends the other shaft. Thus a constant current is formed; down one shaft, through the passages of the mine, and up the second shaft. There are several objections to the use of furnaces, however, and now very often ventilation is secured by very large fans made to revolve very rapidly at the top of one of the shafts. These fans, as it were, pump the air up the shaft.

2. *Lighting.*—If a piece of wire gauze is held close over a gas-jet, and the gas lit, the gauze may be removed several inches above the jet and the gas below will not take fire —there will be a flame only *above* the gauze. This is because the metal gauze takes away so much of the heat that the gas below is too cool to ignite.

In the safety-lamp of Sir Humphry Davy, the flame of the oil-lamp is surrounded by wire gauze; and although most inflammable gas may be around the lamp, and even burning inside it, no flame will pass through the wire cage.

(For an account of modern improvements in ventilation and lighting of coal-mines, see *History of Coal-mining*, by R. L. Galloway, chaps. xx. and xvi.; and vol. ii. Bevan's *British Industries.*)

Kinds of coal:

1. **Anthracite** is the heaviest kind; it is stony-looking, often shining, and when pure, it does not stain the fingers. It is difficult to burn, but when once kindled, it gives off great heat and little smoke. This coal is found largely in Wales, and in the United States.

2. **Cannel coal,** sometimes called 'parrot' coal because of the crackling noise it makes when thrown in the fire. Like anthracite, it is often made into ornaments such as

beads, inkstands, vases, &c. It is said that at a time when this coal was little known, the Duke of Bridgewater, having found some by the side of his canal, had a dinner-set made of it; and when his guests had dined, the dishes were, to their great amusement, thrown on the fire. It is the coal from which gas, especially in Scotland, is obtained.

3. **Household coal.**—This is the kind usually employed for burning in common fires. There are three chief varieties:

Caking coal.—This, when burning, gives out a black substance which unites many pieces into one pasty mass.

Cherry coal is like caking coal before burning, but does not, when heated, form a cake.

Splint coal is sometimes called slate coal. The laminated texture is more distinct in this than in the other two sorts, and it is a good deal harder to break.

4. **Brown coal, or lignite.**—This coal varies much in appearance. When fibrous, it is similar to wood, but usually it is more like common coal except in colour: it is often earthy. Although not largely used in the British Islands, it is an important fuel on the continent. Paraffin oil is made from it in Germany. In England, it is worked chiefly at Bovey Tracey, in Devonshire.

Uses.—Besides the converting of water into steam as a source of power to drive machinery, it is from coal we derive heat for domestic purposes, and the gas which lights streets and houses. In the manufacture of gas, tar is obtained, which yields a material from which, by combination with other substances, many beautiful dyes are prepared. Coal probably came into use through being exposed by falling portions of cliff on the seashore, which, perhaps, gave rise to the name 'sea-coal,' by which coal was long known. It is, however, generally

said that this name was given to it because it was brought to London by sea. As early as 1228, a lane out of London was called 'Sacole Lane' (Sea-coal Lane), showing that some trade in coal was at that time going on there. At first, coal was merely used by smiths and the like, and as the use of it spread, the smoke it gave rise to became, with the inefficient ventilation of that day, a very great nuisance. Accordingly, in the reign of Edward I., the use of coal in London was prohibited by a royal proclamation. Not half a century later, however, Edward III. interested himself greatly in the coal trade. Two centuries later still, Henry VIII. ordered 3000 chaldrons of coal to be forwarded to Boulogne, and a letter of that time speaks of Newcastle coal as 'that thinge that France can lyve no more withowte than the fyshe withowte water.'

In consequence of the scarcity of wood, the use of coal in London became once more general in the sixteenth century. In later days, the invention of the steam-engine, and the great increase in the iron trade, have developed still more the use of coal.

IRON.

Iron ores, and how they are found.—Native iron, that is, iron in a nearly pure state, is found only in small quantities on the earth's surface. It occurs chiefly in the form of meteorites which have descended from bodies beyond the earth's atmosphere.

Iron is usually found combined with other substances, for example, oxygen, carbonic acid, clay, sulphur, and phosphorus. A very large proportion of iron ores are found in the vicinity of coal seams, and are worked in connection with the coal.

The *chief iron-ores* are:

Magnetic iron ore.
Red hæmatite.
Sparry carbonate of iron.
Clay-band ironstone.

Iron in common use exists in three forms:

(1) Wrought or nearly pure iron.
(2) Cast-iron, a compound of iron and carbon in its purest state.
(3) Steel is iron combined with a very small proportion of carbon.

How iron is extracted from the ore.—*General account.*—When iron is united with oxygen only, as it is in magnetic iron ore which has been so long known as **lodestone**, there is not very great difficulty in extracting the iron. The only thing to be done is to use a substance which will attract the oxygen more powerfully than the iron can. This, charcoal or carbon is found to do when heated—it separates the oxygen from the iron, and converts the latter into a comparatively pure cast-iron.

In certain parts of Great Britain a good deal of hæmatite iron ore is found, which also consists, in its pure state, of iron and oxygen only. The cast-iron or pig-iron obtained from this ore is very largely used in the manufacture of cheap steel.

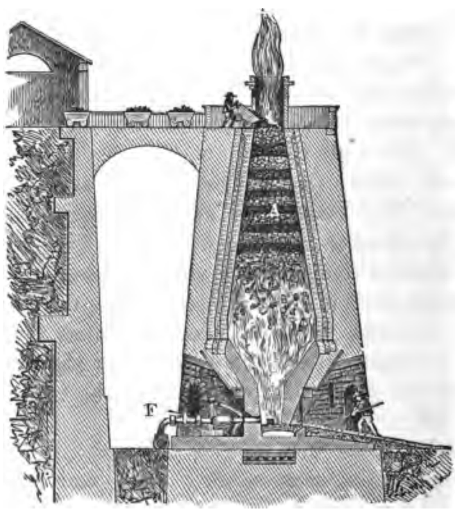
But most of the iron ores used for making British iron contain impurities such as clay, sand, and other bodies, which render the extraction of the iron from them a difficult operation. They require a preliminary roasting, and when put into the smelting-furnace along with fuel, a supply of lime is also put in to carry off the impurities by forming with them a fusible 'slag.' The lime is called a 'flux,' and the slag is a kind of coarse glass.

(See Bevan's *British Industries*, vol. i.)

Processes in the preparation of pig-iron:

1. *Roasting.*—Common or clay iron ore having been broken into small lumps, is laid on heaps, and mixed with coal, which is then set on fire, and allowed to slowly burn. This drives off the carbonic acid, and converts the ore into an oxide of iron. It also dissipates the small amount of water usually present.

2. *Smelting.*—The ore having been thus roasted, is thrown, together with coal and limestone, into a blast-furnace.



Section of Iron Blast-furnace, showing the method of feeding in the ore, &c. through the openings at the top. At F is the pipe through which the hot air is forced into the furnace to increase the heat.

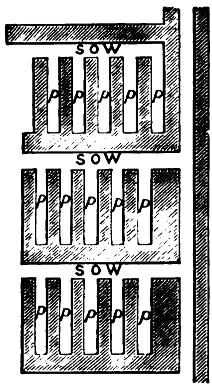
A blast-furnace is a hollow tower from 30 to 100 feet in height, the parts of which can be readily seen from the accompanying figure. It is lined with fire-bricks. The air

blown through these twyers, or blast-pipes, is generally heated, for this is found to be much more economical than if a cold blast is used; there is less fuel required, and the blast itself is heated by making use of the gases, which were before allowed to escape from the top of the furnace.

Outward View of Blast-furnace, showing (at D) the molten iron running off into the moulds to form pig-iron.

Action of the Blast-furnace.—In this country the rich and poor ores of iron are mixed together, the charge consisting of about one part of limestone and two of coke to three parts of ore. As the iron is melted, it sinks, undergoing various changes in its descent, to the lower part of the furnace. The melted slag being lighter, floats on the top of the molten iron, and is drawn off at intervals. The iron is afterwards tapped and drawn off free of the

slag. The moulds into which the iron is made to run consist of long lines called 'sows,' from which run short parallel lines about three or four feet long, called 'pigs.' The iron thus formed is called 'pig-iron.'



Moulds of sand, in which 'pig-iron' is formed.

(See *Iron and Steel*, by W. Greenwood, 1884.)

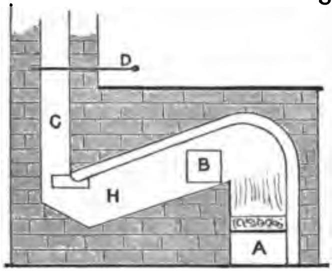
How pig-iron is made into wrought-iron.—In order to change pig-iron into wrought-iron, able to bear great strain without breaking, it must be robbed of carbon, as well as purified from sulphur and certain other substances, especially phosphorus. A very small portion of the last-named impurity will render the iron brittle and unfit for ordinary use. These changes in pig-iron are produced by refining, puddling, and rolling.

Refining.—Pig-iron is placed with purest coke in the refinery furnace. Pointing down upon these materials are six twyers, through which a cold blast is directed. In about two hours after the coke has ignited, the metal is melted and runs to the bottom. At one side of the hearth there is a tap-hole which opens into a mould. Into this mould the molten iron and slag run, and the latter being the lighter, floats on the surface. As soon as the mould is filled, water is run in, and by this means, both the iron and the slag are very rapidly cooled—the iron being rendered so brittle that it may readily be broken into pieces with a sledge-hammer.

All impurities are not yet removed, and, accordingly, the broken pieces of refined iron pass next to the puddler's furnace.

Puddling.—In the reverberatory furnace the flames pass

over the iron as it lies on the hearth. A is the ash-pit, over which the grate is placed containing the fuel. B is a door in the side, through which the workman introduces a long iron rod, and puddles the metal. H is the hearth where the lumps of iron from the refinery are placed. C is the chimney by which the flame and smoke escape, and which is provided with a damper, D, to allow of the draught being regulated.



As soon as the charge of refined iron is melted on the bed of the puddling furnace, the puddler, with his bar or rabble, stirs it about to expose it to the oxygen in the mixture of gases passing over it, and to incorporate it with some **hammer scale** obtained in the forging process, and the slag called **cinder,** formed during a previous puddling operation, both of which are oxides of iron. Before the end of the process, the reaction of these on the iron gets rid of the carbon and various impurities. When it gets some further stirring with the rabble, the metal becomes pasty, and subsequently coarsely granular. Finally the puddler collects with his bar these granular pieces, now capable of being united, into a ball of 70 or 80 lbs. weight.

The puddled ball is removed by large tongs, and conveyed to a powerful hammer, where it is forged into an oblong slab or **bloom.** This is next passed through a series of grooved iron rollers, to form it into puddled bars. These are broken up and formed crosswise into a pile, which is then brought to a welding heat and again rolled. For superior iron this last part of the process is repeated several times, so as to completely remove all cinder, and make the iron compact and malleable.

Steel.—Cast-iron contains 3 to 5 per cent. of carbon.

Wrought-iron practically contains no carbon.

Steel contains about 1 per cent. of carbon.

It will be seen, therefore, that steel may be produced either by adding carbon to wrought-iron, or by taking away some of the carbon from cast-iron. The former is effected in the following way: Upon the hearth of a furnace, which is in shape like a glass-furnace, are placed two fire-brick troughs or boxes. Upon the bottom of each of these troughs is first spread some charcoal, and upon this a layer of wrought-iron bars. Upon this again more charcoal, and next another layer of bars, until the trough is full. The surface of the last layer is then plastered over with that mud which collects in the trough of a grindstone used for sharpening cutlery. When the contents of the troughs are completely sealed up from the air, a fire is lighted upon the grate, and the temperature rises for about forty-eight hours, after which it is steadily maintained for seven or nine days. The rate at which the change into steel is taking place is ascertained by removing from time to time a 'trial-bar.' When this test-bar shows that the carbon has sufficiently penetrated the iron to convert it wholly into steel, the bars are removed.

The steel has a blistered appearance, and requires to undergo further treatment to make it into tilted, shear steel, or cast steel.

By the above process, fine steel, such as that used for tools and cutlery, is made. But a commoner steel for large objects is now much more largely made by what is called the Bessemer process. It is most simply conducted as follows: Five, or sometimes ten, tons of pig iron, obtained from a pure ore, are run in a molten state into a large iron vessel lined with fire-brick, and called a converter. By a peculiar arrangement air is then blown in with great

force at the bottom of this vessel, passes through the melted metal, and in doing this the oxygen of the air forms a compound with the carbon of the pig-iron, and carries it off. By nice management the air-blast can be stopped in time to leave just sufficient carbon in the metal to convert it into steel, when it is poured into moulds for use. But this seemingly simple operation is really difficult to do successfully, so that the carbon is now wholly 'blown off' in the converter, and the proper quantity of carbon added again by pouring in a little of a pure kind of pig-iron.

It has recently become possible to make steel from common pig-iron, smelted from impure ores, on the Bessemer plan, by using a peculiar lining for the converter.

Some of the uses of iron:

1. *Of Cast-iron.*—For cylinders and other heavy parts of steam-engines; for fire-grates, gas and water pipes of large size, pillars, railings, and ordinary pots and pans. These are all made by pouring the melted cast-iron into moulds.

2. *Malleable or Wrought-iron.*—For connecting-rods and the lighter parts of steam-engines; for the armour-plates of war-ships as well as the thinner plates of merchant ships and boiler plates; for chains, wire, locks, keys, and hinges. Wrought-iron not being fusible, objects made of it require to be forged or formed in some other way than by casting it.

3. *Of Steel.*—Some kinds are used in the same way as wrought-iron for large objects such as ship plates, artillery guns, wheel tires, axles, and rails. Fine steel is used for springs, tools, and cutlery, as it can be tempered to almost any degree of hardness.

Some objects such as bridges and girders may be made of cast-iron, wrought-iron, or steel; but the weight and form of these differ, according to which of the three happens to be used. They are lightest when made of steel, and heaviest when formed of cast-iron.

SOAP.

Hard soap is formed by the action of soda-lye upon oils or fats.

Soda-lye may be thus produced: Common soda is dissolved in water; some lime is added, and the whole boiled. Whiting settles to the bottom, and the liquid which is poured off is soda-lye.

Fats and oils used.—Fatty substances of both animal and vegetable origin are used. Tallow, kitchen-stuff, lard, fish oil, seal oil, palm oil, olive oil, cocoa-nut oil, and cotton-seed oil. All these vegetable oils are obtained from plants grown out of Great Britain. Some of them are pressed out of the seeds after the latter have been imported —the residue, the oil-cakes, being used for fattening cattle.

Rosin, obtained from pine trees, which is not properly a fat, is also used.

How soap is made.—Into a large vessel—a soap-pan, sometimes measuring as much as 15 feet deep and 15 feet across—the oil or fat is put. Soda-lye is then added, and this mixture warmed and then boiled. Stronger lye is added several times, and the boiling is continued until the soda has completely acted upon the fat, that is, until soap has been formed by the union of the soda with the fatty acid of the fat. At the same time the glycerine of the fat separates and dissolves in the water. The soap has now to be separated from the liquor. This is brought about by adding common salt to the fluid, soap being insoluble in very salt water. About 10 lbs. of salt are added for every 100 lbs. of fat used.

The soap now forms a layer which floats on the top, and may be drawn off; or the watery part may be run off,

leaving the soap in the pan. This soap is then boiled again with more lye, and after the mixture has settled, the liquor is again let off, and the soap is moulded and cut into bars.

Kinds of hard soap:

1. White or curd soap, made chiefly from tallow.
2. Yellow soap, which contains rosin as well as tallow or vegetable oil.
3. Mottled soap, the mottling of which is produced by compounds of iron.
4. Castille or Marseilles soap, formed of olive oil, with cotton-seed oil and some cheap oils added.

All these hard soaps are of course made with the addition of soda to the fatty materials named, as explained above.

5. Fancy soaps, for example, brown Windsor, &c., are chiefly prepared from curd soap by re-melting and skimming. Scents, such as bergamot, caraway, thyme, &c., are often added. Colouring matters are often introduced; thus the colour of brown Windsor is produced by burnt umber and ochre, or in some cases, burnt sugar. Transparent soap is made by dissolving curd soap in spirits of wine, adding perfume, distilling off some of the spirit, and then pouring the liquid into moulds.

Good soap should be firm to the touch, and should contract but slightly when drying.

Soft soap is made by boiling fish oils, seal and whale oils, linseed and other vegetable oils, with a lye of potash. The latter is made by boiling the ashes of plants with water and lime. When the potash-lye has completely acted upon the fats, instead of adding salt, the mixture is boiled down. This evaporates a great deal of the water; but the soft soap left behind contains considerably more water than hard soap does. As this soap is made from fish oils and

other matters having an offensive smell, it is used chiefly in cleaning such things as woollen stuffs, floors of houses and public buildings, &c.

Importance of the soap manufacture.—It has been said that the extent to which a country is civilised is shown by the amount of soap which it uses. Both the production and the consumption of soap in England are greater than in any other country. It is during the last thirty years that this industry has become of such importance. In 1852, when the soap duty was abolished, not less than 1600 tons per week were produced. By 1870 the produce had doubled, and now it is probably over 4000 tons weekly.

As the most costly of the materials used in soap-making, namely, the fats and oils, are chiefly imported into this country, the extent of the soap manufacture must be largely due to the cheap production of soda in England.

GLASS.

Kinds.—Besides bottle-glass, there are two kinds in ordinary use:

1. **Window-glass**, which consists of sheet, crown, and plate.

2. **Flint-glass**, which is used for tumblers, decanters, &c.

Materials.—Sand, with soda or potash, and lime; or in some kinds, oxide of lead takes the place of lime.

The materials for making different kinds of glass vary somewhat. Thus, the sand and other substances required for flint-glass must be as pure as possible. One of the worst impurities is iron, which in some forms gives a green, and in others a yellow colour to the glass. These effects of the iron have to be counteracted by the

addition of some other substance, usually a compound of either arsenic or manganese.

Glass-pots.—The pots or crucibles, in which the ingredients of the glass require to be melted, are made of a refractory fire-clay carefully freed from impurities. The clay is ground, then moistened with warm water and well mixed together. This mixture is then left for a time. Meanwhile, some old crucibles are ground fine and mixed with the fire-clay. After being formed of the size and shape required, the crucibles are allowed to remain for at least several months in the room in which they were made, in order that they may gradually dry. They are then placed in a furnace and heated up to a red heat.

The glass-pots for bottle and crown glass are open at the top. Those for flint-glass have a dome-shaped covering at the top with an opening in front.

Manufacture of window-glass:

1. *Fritting.*—Ordinary sand (if it does not contain much iron), soda, and lime, with small quantities of arsenic, manganese, and anthracite coal, are mixed together. These ingredients are placed in a furnace and heated for some time. By this means the mixture is dried, and carbonic acid gas is driven off.

2. *Founding.*—After this, the 'fritt,' as this mixture is called, is put into a glass-pot in the working furnace. The flames here pass over the open top of the pot, and in eight or nine hours the fritt is melted into glass. More fritt is then added, and in about sixteen or seventeen hours the whole is melted. A scum which has risen to the top is now removed by iron ladles. Some broken glass is next thrown in, a little at a time. This brings to the surface any further impurity, and this is in turn removed; after which the glass is heated for some hours.

3. *Blowing of sheet-glass.*—After allowing the glass to cool a little, so as to form a pasty mass, the workman introduces the end of an iron tube into the furnace, and collects on it about 10 lbs. of the soft glass—and this he blows out into the form of a globe. Holding the tube perpendicularly for a few seconds with the loaded end downwards, the workman causes the softened globe to become pear-shaped. This, by swinging, he next changes into a cylinder with rounded ends. After this cylinder is detached from the blowpipe and its ends removed, it is cut down lengthways with a diamond, laid open, and flattened in the flattening kiln.

It is then removed to a hot room, where it is very slowly cooled. This gradual cooling is called *annealing*. If glass from the furnace is *suddenly* cooled, it becomes very brittle. Thus, molten glass dropped into water, contracts on the outside before the internal parts have had time to cool, and their particles to rearrange themselves. Hence, if the outside of such a piece of glass be broken, the whole flies to pieces.

(See *Heat*, by Tyndall, sect. 106.)

Manufacture of plate-glass.—The materials, which are of the same kind, but of purer quality than those used for common window-glass, are placed in glass-pots having grooves around the sides. By the application of metal claspers to these grooves, the pot can be removed from the furnace and emptied out upon a smooth iron table. The contents of the glass-pot fall out in as pasty a condition as a lump of dough. A roller now passes quickly over this soft glass and spreads it out evenly—strips along the edge of the table regulating the thickness of the glass. The plate thus formed is then removed, while hot, to an annealing furnace, and cooled very slowly.

As the plate of glass at this stage is rough, both sides

require to be ground and polished. Two plates are placed face to face with sand and water between them, and the upper one moved by means of machinery backwards and forwards over the lower, which is fixed; in the same way they are next rubbed with emery powder and water, and finally polished with leather buffers and the use of finely divided oxide of iron and water. The chief reason of the high price of plate-glass is that the processes of grinding and polishing it take much time.

Flint-glass.—This is not really made of flint, but of the white sand from Alum Bay, in the Isle of Wight. Instead of soda, potash is added, and red-lead instead of lime. The glass-pots used for this glass are covered, and the melting, therefore, takes much longer time. When the glass has become workable, an iron tube is thrust into the pot, and the required quantity of glass is lifted out upon its end. The tube is then held perpendicularly, and the glass is blown out into a globe. An iron rod called a **pontil** or **pontee** is then applied to the end farthest from the tube. The tube is next detached by touching the glass nearest to it with a piece of cold wetted iron. The workman then takes the pontil with the glass attached, and, sitting down, rests the pontil across the smooth level arms with which his chair is furnished.

He is provided with a pair of small iron tongs, shears, compasses, and a scale of inches, and while, with his left hand, he rolls the pontil backwards and forwards, he uses his right hand in shaping, by means of these various instruments, the glass which he is required to make, which may be a tumbler or wine-glass. When accurately formed, the glass is separated from the pontil, and taken to the annealing furnace.

Looking-glasses.—The oldest and still common method of making these is by coating one surface of plate-glass

with an amalgam of quicksilver and tin, which is called **silvering**, although there is no true silver used. Mirrors are, however, also made by depositing real silver on the glass, and then protecting it from impure air, which would blacken silver, by a 'composition' or varnish.

Coloured glasses.—There are certain metals which, when present among the materials used for producing glass, impart to it peculiar colours.

Thus iron gives the glass either a green or a yellow colour. Copper imparts a red or a green colour. Manganese, purple. Chromium colours glass a beautiful green. Gold gives it a ruby or crimson tint. Cobalt produces a blue colour.

(For an account of *Glass-painting*, see Bevan's *British Industries*, vol. vii., pp. 98–108.)

Early use of glass, &c.—The story goes that some Phœnician merchants, while cooking their food on the sea-shore, noticed that the ashes of the plant with which they had made their fire caused some of the sand to be fused into a glistening mass.

But glass was known long before this by Egyptians, and the mummies in the British Museum are decorated with beads and other ornaments of glass.

Glass was very long in use before windows were made of it. In Rome, thin pieces of talc, or thin plates of agate or marble, were used for windows.

The Chinese had for their windows very fine cloth covered with a shiny varnish, or in other cases, split oyster shells or thin plates of horn. The Japanese use oiled paper.

The earliest certain record of the use of glass for windows refers to the time of Constantine the Great—in the fourth century. Glass for church windows is said to have been introduced into this country in 674 A.D.

Ordinary window-glass was first made in London in 1557. At the present day, glass is made at many places in Great Britain, the chief of which are St Helen's, Warrington, Birmingham, Newcastle-on-Tyne, and Stourbridge.

PAPER.

Materials:

Linen rags, flax-tow, and refuse.
Cotton rags and cotton-waste.
Old ropes and coarse bags of hemp.
Jute and Manilla hemp waste.
Esparto grass, wood of various kinds, straw, and maize-husks.

Preparation of materials:

Rags.—1. *Sorting and cutting.*—Linen rags need to be sorted from cotton rags, and each of these again into two or three qualities and colours. Buttons, pins, and the like, are removed by women and girls, who stand at tables in the rag-house. In the middle of each table is fixed a sharp, scythe-shaped knife, by which all seams in the rags are undone, and the stuff cut into three or four inches square. Buttons, hooks, pins, &c., as they are removed, fall through a grating in the table into a drawer.

2. *Dusting.*—After being cut up into small pieces, the rags are dashed about in a willowing machine armed with spikes, and are passed through a revolving cylinder of wire-work. By this means, they are freed as much as possible from dust and dirt.

In the best mills, a first dusting takes place before the sorting and cutting, so as to make the work less unwholesome for those employed at it.

3. *Boiling.*—The rags are next boiled in a huge cylindrical or spherical shaped vessel containing water, to which soda and sometimes lime have been added. This boiler is made to revolve slowly, and the stirring thus caused, together with the action of the soda and lime, remove grease stains and colouring matter.

4. *Washing and breaking.*—The boiled rags are next torn in pieces by a machine called a 'breaker.' This machine contains a drum-shaped wheel which is covered with many sharp teeth, and which is made to turn quickly round near another set of fixed teeth. As the rags are floating in water, they are drawn in between the teeth, which somewhat resemble knife-blades, and reduced almost to a pulp. Clean water is constantly kept flowing into this machine.

5. *Bleaching in poaching engine.*—The breaker or breaking engine just described, the poaching engine used for bleaching, and the beating engine for completing the reduction of the pulp, are all similar in construction. They are placed at different levels, so that the contents of the first may easily flow into the second, and then into the third. In the poaching engine the 'half-stuff,' as the pulpy torn-up rags at this stage are called, is bleached, by adding bleaching liquor (chloride of lime). But sometimes it is only partially bleached here, and is then transferred to bleaching tanks.

6. *Beating process.*—In the beating engine the 'half-stuff' is reduced to a pulp of the proper degree of fineness. The drum in the poaching and beating engines is driven at a slower rate than in the 'breaker.'

Esparto is a grass growing in the south of Spain and in Algiers, where it has been used from the earliest times for basket-making. It is imported into this country now in very large quantities, and arrives in bales tightly compressed. The first step in the preparation of this article

for use is to carefully pick it over, to remove any roots or pieces of other grasses. It is next boiled in soda, which greatly softens it, and after undergoing a second picking, it is broken down, bleached, &c., in the same way as rags.

The fibre of several kinds of wood—willow and yellow pine being very suitable—and wheat straw are also a good deal used for inferior papers. Indeed the materials which either are or can be used in paper-making are numerous.

Manufacture:

By hand.—Into the pulp, which looks something like milk-and-water, the workman dips a sort of shallow tray, the bottom of which is formed of fine wire gauze. The water drains off, and a sheet of pulp is left behind.

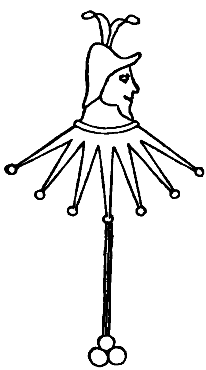
Another workman takes the mould containing this sheet of pulp, and turns it over on to a sheet of felt, to which the pulp readily adheres. Upon this is then placed another sheet of felt, and upon this again another layer of pulp. When a pile of from four to eight quires of paper, with intervening sheets of felt, is formed, the whole is powerfully compressed.

The paper, which can now be removed, is like **blotting-paper**. In order to make this fit to write upon, it is dipped into size, and dried slowly. A gelatin size, made of parings of animal skins, is used for writing, and a rosin size for printing papers. To give paper a smooth and glossy appearance, it is pressed between hot rollers of polished steel. It is then ready to be done up into half-quires or quires. Paper-making by hand is not very largely carried on except in Holland.

By machinery.—The processes are much the same as in hand-making, but go on a great deal quicker. The pulp is allowed to flow over from a vat on to an endless piece of wire-cloth, which is kept moving over a series of

rollers placed horizontally. In this way, a continuous sheet of pulp is carried along, being drained as it goes by various contrivances. It is then passed between rollers covered with felt, by which more water is squeezed out. After this, by being carried over hot rollers, it is finally dried, and then wound upon a reel as paper, which only needs to be sized and rolled to be finished. A paper-making machine is a very beautiful piece of apparatus, and owing to the care with which the surfaces of its numerous rollers require to be prepared it is also very costly. Few pieces of machinery are more interesting to see in operation.

Water-marks in paper.—In machine-made paper, marks are produced by carrying the slightly hardening pulp over a cylinder of brass wire with the device woven in. This cylinder turns round, and with slight pressure makes marks upon the paper which no subsequent operations will remove. In hand-made paper, the mark is woven into the wire-cloth upon which the pulp is drained.



Many of the marks formerly used were curious, and the names which are now often employed to describe different sizes and sorts of paper have been obtained from these. Thus paper with the mark of a hand and a star upon it was in use in 1530, and perhaps gave the name to what is still called 'hand' paper.

'Foolscap' was a mark used for a time, the figure having a cap and bells. Nowadays, paper of this size is usually

marked with a figure of Britannia, although the old name is still used to describe the particular size.

(See *Paper and Paper-making*, by R. Herring, pp. 78–90.)

Materials for writing before invention of paper. —Mankind have used very varied materials from time to time upon which to write. The most ancient remains of writing which have been handed down to us are upon such substances as bricks, stones, and metals.

In very early times, the Greeks and Romans used either plain wooden boards, or boards covered with wax. Such 'tables' were in use until the fourteenth century, and even in our own day, tablet books of ivory are occasionally used.

The leaves of certain trees, such as the palm, olive, and poplar, seem to have gradually taken the place of boards as articles whereon to write. Perhaps it is on this account that to the present day we still speak of a single sheet of a book as a 'leaf.' An iron style was used for marking the letters or characters. The leaves were then rubbed with soot, or some dark colouring substance, and the scratched parts by this means were more readily seen.

Before the art of paper-making was known to the Chinese, they used silk, on which they painted the letters. In later times, prepared skins or parchments came into use for this purpose. These skins were rolled—each roll being called *volumen* by the Romans. From this Latin name our word 'volume' has been derived.

The word 'paper' was derived from *papyrus*, the name of a celebrated plant growing in the swamps of Upper Egypt, once largely used by the Egyptians for making baskets, &c. The papyrus is a species of grass, and the ancients made paper from it by slicing the stem, and then joining, pressing, and hammering the slices into a sheet, which was finally smoothed with a piece of ivory. The pen

used was a reed cut and split somewhat similarly to a quill, but with a point less sharp.

The art of making paper from vegetable matter reduced to a pulp was not practised in Europe until about the fourteenth century, although it was known in China long before that time. The first paper-mill in England is commonly said to have been erected at Dartford in 1588, by Sir John Spielman.

Shakspeare refers to a paper-mill, perhaps this very one, although he makes it to be standing nearly two hundred years before the above date. (See *Henry VI., Part II.*, act iv., sc. 7, where Jack Cade accuses Lord Say in these words: 'Contrary to the king, his crown, and dignity, thou hast built a paper-mill.')

It is likely, however, that paper-mills were in existence in England before the one built by Spielman, because in a book printed by Caxton about 1490, there occurs a reference to John Tate,

> Which late hathe in England doo make thys paper thynne
> That now in our Englyssh thys book is prynted inne,

whose mill was at Stevenage, in Herts.

PINS.

How made.—The material of which most pins are made is brass wire, which is unwound from a reel, and then straightened by being drawn between several smooth, round, iron spikes, which are driven into a bench. After being by this means straightened, the wire is led to the punch, which, with one blow, forms the head of the future pin. By a pair of nippers, worked by machinery, a piece of wire, the length the pin is to be, is next cut off. This slides down a grooved incline, and falls into a tray, the bottom

of which has a slit in it, to let the shank of the pin drop through. Suspended by their heads, the pins move down the slit, rotating meanwhile in front of a narrow steel roller cut with file teeth, which diminish in coarseness from one end to the other. The roller operating on the ends of the pins points them, and at the same time smooths the points.

Colouring.—The pins are next brightened. To effect this, they are first boiled in weak beer, to remove any grease. They are then placed in layers in a copper pan, the layers being separated by grain-tin, that is, tin in the form of tears or granules. Water is poured in, and cream of tartar, which is a substance formed by the union of tartaric acid and potash, is sprinkled on the surface of the water. The pan is heated, and by the action of the acid a solution of tin is formed. When the pins are taken out, they are found to be 'whitened' or 'coloured' by the tin which has been deposited upon them. They are brightened by being shaken with bran or sawdust in a leather bag; after which the pins are sifted out.

The blue tinge of mourning pins, which are made of iron wire, is produced by heating them upon an iron plate. If a dead-black colour is required, they are dipped in black varnish and dried in a stove.

Papering.—The pins which are not to be sold in packets are next stuck into sheets of paper. This is done nowadays by machinery.

Contrast of the present with the old method.—By the method briefly stated above, a pin need pass, in making, through the hands of three individuals only—the man who attends to the machine, the colourer, and the paperer.

By the old method, sixteen individuals were employed in

the eighteen processes of pin-making. The pin, instead of being formed of one piece, as at present, was fitted with a head of finer wire than that composing the pin-stalk.

Kinds of pins.—The 'sets' are distinguished by twelve numbers or letters. Some, such for instance as blanket pins, are from 2 to $3\frac{1}{2}$ inches long. Domestic pins are from half an inch to one and a half inches long. Some are formed of very slender wire; others, again, are $\frac{1}{16}$th of an inch thick.

The shapes, too, vary; some being so bent that the point, after passing through the folds of the dress, rests in a loop, which prevents its scratching. Pins vary a good deal in value. Thus those of ordinary make are sold at 1s. 4d. per lb., while fine pins used by insect collectors fetch as much as 112s. or 128s. per lb.

Where pins are made.—Pins were first made of bronze. Such pins have been found in the sepulchres of Egypt. Pins are said to have been introduced into England from France in 1543 by the last queen of Henry VIII. Then, as now, the best pins were made of brass, although many others were made of iron wire. The first pin manufactory in this country was established at Gloucester in 1626. The factories at Stroud were long celebrated. Soon the trade found its way to Bristol and Birmingham. The latter place is now the chief seat of the industry.

About fifty millions of pins are produced daily in England. Of these, Birmingham alone produces thirty-seven millions. The remaining thirteen millions are manufactured at London, Warrington, and Stroud.

Pins are made in small quantities in France, Germany, and Austria; but America is the only country which approaches England in the extent of this industry.

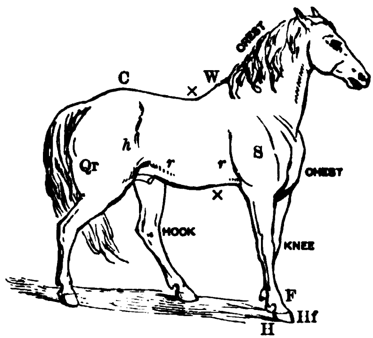
Value of the manufacture.—The weight of wire

annually used in the United Kingdom is more than 1200 tons. Of this amount, the brass wire costs about £115,000, and the iron wire over £7000. The wages, paper, wear of machinery, and profit must bring the value of the pin manufacture for this country up to £220,000 a year.

THE HORSE.

General description.—Some of the points looked to in a horse are:

1. *The size of the forehead.*—As the brain is situated here, the larger the forehead, the larger may this organ be considered to be; and a well-developed brain will mean courage, intelligence, and good temper.



W, withers; S, shoulder-blade; ×....×, girth; *r*....*r*, ribs; C, croup; *h*, hip; Qr., the quarters; F, fetlock, or pastern joint; Hf., foot or hoof; H, heel.

2. *The eye.*—If full and clear, with a soft, gazelle-like expression, the animal rarely has a bad temper.

3. *The nostrils* in all cases should be wide and open.

4. *The shoulder-blade* should be as nearly upright as possible for cart-horses; but in horses required for speed, the more slanting it is the better.

5. *The chest.*—The capacity of the lungs is marked by the size of the chest at the girth; but in the racehorse and hunter this capacity is obtained by depth rather than

width, for a wide chest interferes with the rapid action of the shoulders.

The height of the horse is measured at the withers and croup, and is counted in 'hands,' each being four inches. An average height for a racehorse is about $15\frac{3}{4}$ hands, that is, 63 inches.

The age, up to a certain time, can be determined by the teeth.

When the foal is born, it has all the first set of teeth except the outer incisors or nippers. Five days after birth, these four teeth in front, called the nippers, begin to shoot, and are fully grown before the animal is nine months old. These are cast off at the age of two years and a half, but are soon renewed. In the following year, two above and two below, one on each side of the nippers, are also thrown off. At four years and a half, other four; next, those last placed fall out, and are succeeded by other four, which grow much more slowly. From these four, which are corner teeth, the age is determined, for they are somewhat hollowed in the middle, and contain a black mark, caused by the masticated food. This black mark disappears at eight or nine years, for by that time the teeth have been worn down. The average age of the horse, free from accidents, is about twenty-five years. Occasionally he has reached thirty-five, or even forty, but this is rare. Even the best cared for become quite worn out soon after their twentieth year, and if allowed to live, they waste away, and die by degrees somewhere between twenty-three and twenty-eight years.

Habits.—In a wild state, the horse finds his safety in flight, although, if obliged to fight, he uses his teeth and heels powerfully. He is able to make longer journeys without fatigue than the domesticated horse can. Thus South American and Californian horses, after being taken

with the **lasso**, will carry a rider many miles straight off at a furious gallop.

The horse sheds his coat once a year in all countries. The hair of the mane and tail is constantly growing.

The horse is not so intelligent as the dog, but can be made to understand what is said to him, as may be readily seen from watching a farm-horse ploughing, or a horse at a circus. The brain does not seem to need much rest by sleep, four or five hours being generally sufficient. This rest is taken frequently while standing—some horses never lie down—but the practice is said to produce fever in the feet and other disorders.

Food.—Grass (green or dried), oats, beans, peas, Indian corn, chaff, carrots, and turnips. Camel's milk forms the food of horses in the Arabian deserts, when a supply of the usual food is deficient.

The amount of water required varies with the work the horse does, and, to a certain extent, it varies also with the food eaten. Horses should not be allowed to drink largely when they are heated, nor when they are about to be put to fast work.

The stomach of the horse is remarkably small, and suited to a digestion which has to be continuous, not being separated by intervals, as it is in the case of ruminants and carnivora. This enables the horse to exert his utmost strength at any time, which he certainly could not do if he had to carry a mass of undigested provender in his stomach.

Locomotion.—Horses in a wild state have probably but two paces—the walk and the gallop. The domestic horse, however, has, at least, four—the walk, trot, canter, and gallop.

When a horse, which has been standing in an easy, natural position, starts to walk, he begins with one of the

hind-feet, next follows the fore-foot of the same side, then the hind-foot of the opposite side, and lastly, the fore-foot also of that side. The average walk of a good horse is about four miles an hour.

In the trot, the diagonal limbs (that is, the 'near'-hind and the 'off'-fore) move exactly together.

The gallop is a succession of leaps, all the feet being off the ground at once. The length of the leap varies with different horses; the distance between the prints of the same feet being in one horse sixteen feet, and in another twenty-four, or as much as twenty-six feet.

The canter is very like the gallop, but in it the feet are said to be never all off the ground together.

(See *The Horse*, by J. H. Walsh.)

History of the use of the horse by man.—The Hebrews, down to the time of David, did not use the horse, although it was well known among the neighbouring nations. David, after a victory over the king of Syria, reserved to himself a hundred horses. Soon after this, Solomon introduced horses largely into Judea. Amongst the Assyrians, horses were commonly employed, and are represented on most of their monuments. They are never shown as carrying baggage or drawing carts, but appear to have been reserved for war or the chase.

The Greeks paid much attention to their horses, and seldom used them for farm-work. The early Greeks used no bit or bridle.

The curb bit was used by the Romans, but no stirrup. The earliest period at which it can be proved that the stirrup was used was at the Norman Conquest of this country. Shoeing was not practised by Greeks or Romans.

(See also *Natural History of the Ancients*, pp. 84–92, by Rev. W. Houghton.)

THE COW.

General description:

1. *The foot* consists of a pair of toes inclosed in a hoof. It looks as if the toes had been formed by the splitting of the hoof into two parts, and hence the foot is said to be 'cloven.'

2. *The teeth.*—There are no front teeth in the upper jaw. Instead of teeth, there is a hard pad against which the front teeth of the lower jaw strike. The only teeth in the upper jaw are six grinders on each side. In the lower jaw, besides six grinders on each side, there are also eight front teeth. There is a vacant space between the front teeth and the grinders.

3. *Horns.*—From the forehead horns usually grow out, each having a core of bone covered by a sheath of horn. These are rounded and smooth, and not twisted in a spiral manner.

4. *The stomach* has four divisions, sometimes separately called stomachs, namely:

(1) The paunch.
(2) The honeycomb bag.
(3) The manyplies.
(4) The fourth, or rennet stomach.

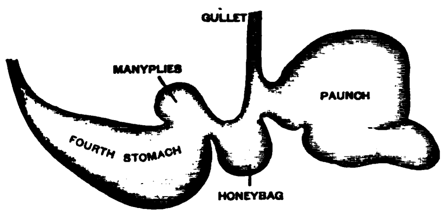
The gullet opens between the first and second stomachs.

The paunch is very large, and opens into the second stomach by a wide aperture.

The second stomach is much smaller than the first, and has its inner surface divided like the cells of a honeycomb.

The 'manyplies' has its inner lining thrown into so many folds that it resembles the leaves of a book, and it has on this account been called the Psalterium or Psalm-book.

The rennet stomach has its inner surface thrown into a few ridges, but it is quite unlike the other three stomachs, and it is here that the most important part of digestion is carried on.



This stomach leads into the intestine or gut.

Chewing the cud.—The cow swallows its food only partly chewed, and then after a longer or shorter time brings it up again in order to chew it more thoroughly. Collecting a bundle of blades of grass with its tongue, it seizes them between the front teeth of the lower jaw and the pad which is in the upper jaw. Then, by a movement of the head, the bundle of grass is torn from the rest with that peculiar sound which is always to be heard while cows are grazing. The grass thus taken into the mouth is slightly chewed, and then hastily swallowed, and passes into the paunch.

After grazing until its appetite is satisfied, the cow lies down and remains quiet for some time. By-and-by a sudden movement occurs, and at the same time a bolus may be seen to be forced up the neck into the mouth. This has come from the first stomach partly through the second, the end of the œsophagus or gullet being at the junction of the first and second stomachs. When this grass has reached the mouth, it is slowly chewed and thoroughly mixed with saliva until it becomes semi-fluid. It is then swallowed again, but this time passes into the third stomach, which strains the food before it reaches the rennet stomach.

(See Huxley's *Anatomy of Vertebrated Animals*, pp. 378–382).

Age, &c.—The young animal is very perfect and vigorous soon after birth, although it needs the care of the mother for a considerable time.

It attains its full strength in about three years.

The average length of a cow's life is about fourteen years.

The animal is subject to many diseases, some of which arise from its habit of licking hairs from its body. These hairs remain in the paunch and form solid balls, of sizes varying from that of a marble to a cricket-ball. If one of these hair-balls be cut with a knife, it is found to be of a spongy character, and when dry, is light, hard, and strong.

Uses to man:

1. Very early in the history of man, the ox-kind was domesticated for his use; the ox is often mentioned in Scripture. Cattle seem to have been used as beasts of burden or of draught before they were valued for their milk; at present the ox is much more frequently employed for ploughing and drawing carts on the continent of Europe and in the East than in Britain.

2. Cow's milk is almost indispensable to man; the cheese, butter, &c., manufactured from it, forming part of his daily food.

3. When killed, cattle yield one of the principal articles of animal food.

4. The skin furnishes man with the greatest part of the leather which he uses.

5. The horns are converted into combs, knife-handles, and the like.

6. Glue is made from the refuse of the skin, the hoofs, and ears.

7. The fat is used in the manufacture of soap and candles.

8. The bones form a cheap substitute for ivory.

9. The hair is used by the plasterer in making mortar.

THE SHEEP.

The wool:

1. The sheep has a coat of wool, not hair. At first sight there seems to be a real difference between hair and wool; but this is not actually the case, for the fibres of both hair and wool spring similarly from roots in the skin. Wool is, however, generally softer, more curled and twisted than hair, and is thus more easily made into thread. A drawing of the magnified appearance of a fibre of wool shows a number of teeth-like projections arranged around it, with their points turned in the opposite direction to the root of the fibre. A hair has similar teeth on its surface, although they are not so sharply defined.

If a single fibre of wool be held up to the light, it will be seen to be twisted in a corkscrew or spiral fashion.

It is owing to these characteristics of the fibre of the sheep's wool, by which it readily felts, that wool is so much valued.

The fibres of wool are moistened on the body of the sheep, with an oily matter called 'the yolk,' which is formed by glands near the root of each fibre. This yolk is not merely a grease or oil—it is more like soap, and dissolves readily in warm water. It keeps the wool soft and flexible.

2. The wool of the same animal differs a good deal in various parts of the body. It is best on the back, shoulders, and sides. In different sheep, and with different food and manner of living, the wool varies greatly.

The chief points to be considered when judging of the value of wool are fineness, softness, pliancy, trueness, that is, evenness of thickness throughout; soundness, that is, freedom from knots and lumps; length and colour.

3. If the winter has not been very cold and food has been abundant, the sheep are covered with a heavy crop of wool, which is generally coarse. If, however, the winter has been very severe, although the sheep may have been supplied with sufficient food, the fleece will be slightly lighter, and the fibres will be finer. If sheep are not properly supplied with food during severely cold weather, the fleece becomes thinner and lighter, and while the fibres are fine, they are weak.

Horns.—The horns of the sheep, like those of the ox, consist of an internal core of bone covered by horn. The projections which grow into horns appear on the head of the young lamb, and arise from the bones of the forehead. They are covered by a part of the skin very thick and hard, and which gradually changes into horn. Polled sheep (those without horns) are quieter, and better to fatten, and for this reason breeds of hornless sheep have been reared, instead of those which, less than a century ago, were horned. Thus the rams of the Romney-Marsh breed were all horned a hundred years ago.

Teeth and age.—The sheep, like the cow, has front teeth in the lower jaw only. The lamb newly born has either no teeth at all, or it has only two front ones. Before the animal is a month old, it has the whole eight front teeth. When about two years old, the two central ones of these front teeth are shed, to make room for more matured ones. Between two and three years old, the two next teeth are shed; and when the sheep is actually three years old, the four central teeth are fully grown. At four years of age, six teeth are fully grown; and at the age of five years, all the teeth are perfectly developed.

In most cases the teeth remain sound for one or two years, after which they get broken off.

Sheep will live and thrive well until they are ten years old; and they may occasionally reach the age of thirteen or fifteen.

(See also *Sheep*, by W. Youatt.)

Food.—The sheep bites closer than the ox. By a half-biting and half-tearing action, some of the grass is torn up by the roots, and some of the mould adhering to them is also swallowed. Harder and tougher herbage than oxen feed upon is eaten by the sheep. Thus the stalks and branches of different kinds of heath are bitten through easily and devoured.

The sheep, by his close bite, not only loosens the roots of grasses, and so causes them to spread, but by cropping off the short suckers and sprouts, causes the grass to throw out fresh and stronger ones. In this way, pasture is made to grow thicker and better by being occasionally eaten down by sheep.

Like the cow, the sheep has four stomachs, and chews the cud.

Habits.—Sheep are not the silly animals they are often represented to be. Like many other creatures which live together in herds, they have a habit of giving a signal of alarm to the rest of the troop when any danger is seen. This they do by stamping loudly upon the ground with their fore-feet, and by uttering a shrill sound.

Nor is the sheep a coward in his natural state. Foxes that have been bold enough to attack flocks of sheep in the mountains of Scotland and Wales, have often paid for their rashness by their lives. A ram is really a formidable foe if he is thoroughly aroused, for, lowering his head, he rushes forward, and charges with his utmost force.

(An encounter between a ram and a tiger, in which the latter was killed, is described in *Mornings in the Zoo*, by Phil Robinson.)

THE REINDEER.

Where found.—It is spread over all the habitable part of the Arctic regions, and the neighbouring countries, being found in Norway and Sweden, Lapland, North Russia, nearly the whole of Siberia; in North America, as far south as the latitude of Quebec; in Newfoundland, Greenland, and Spitzbergen.

General description.—The size varies much according to the locality, those in the more polar regions being the largest. In winter, the hair is long and grayish-brown, except the neck, hinder-quarters, and belly, which are white. In summer, the hair is a dark sooty-brown colour, and those parts which in winter are white, become now gray.

Horns.—Both the female and the male have 'antlers.' These do not consist of a hollow sheath of horn, containing a central bony core, as in the cow and sheep; but, on the contrary, they are bony throughout, and are usually more or less branched. They are annually 'shed' or cast off, and annually reproduced at the breeding season. They increase in size and in number of branches every time they are reproduced, until in old animals they often attain an enormous size. In some wild reindeer, antlers have been observed with as many as twenty-nine points. The horns appear in the young animal within four or five weeks after birth, and at the same time in both sexes. When they are first produced, the horns are simple. The second year's horns have one or two branches, the next more, and so on.

Each year after the horns have reached their full size, a circular ridge makes its appearance at a short distance

from the root of the horn. This ridge is called the 'burr,' and is the point at which the horn falls off. The blood ceases to circulate through the burr, and through the part of the horn beyond it, and consequently both die and are shed.

The rapidity with which the horns grow is very remarkable. With some deer, horns weighing seventy-two pounds have been produced in ten weeks.

(See also Huxley's *Anatomy of Vertebrated Animals*, p. 384.)

Habits.—In its wild state, the reindeer makes annual journeys in the summer from the woods to the hills. This it does in order to escape the swarms of insects which annoy it. An especial annoyance is a gadfly which lays its eggs in the reindeer's hide, as well as in the ears and nostrils, and gives the animal great pain and torment.

During the summer the reindeer feeds upon any green herbage to which it has access; but in the winter the only food is the moss, which often lies deeply buried in the snow, and which the animal cannot reach except by scraping with horns, hoofs, and snout. The reindeer, like the cow and the sheep, possesses four stomachs, and chews the cud. The sense of smell is wonderfully acute, even more so than that of hearing and sight, both of which too are very keen.

Uses to mankind:

1. As a beast of draught and carriage; being used both in drawing sledges and in carrying burdens on its back.

A reindeer can draw 250 or 300 lbs., at a pace of nine or ten miles an hour; but the animal is not usually put to such severe exercise. It has great endurance, and can keep up for twelve hours together.

2. The American reindeer or caribou is not domesticated, but is known only as a wild animal. Its flesh is generally

dry and tasteless; but there is a layer of fat which lies under the skin of the back in the male, and which is highly esteemed.

Under certain circumstances, even the horns are eaten raw if they happen to be young and soft.

3. The skin is very valuable—especially when taken from the young animal—and is found to be, when properly dressed, a good defence against cold and moisture.

THE CAMEL.

The feet are long, terminating in two toes, over which are imperfect, nail-like hoofs, covering no more than the upper surface of each toe. The soles of the feet are covered by hard, horny cushions, by which the two toes are joined, and upon which the animal walks. This form of foot enables it to maintain a firm hold upon the sand over which it often travels.

The knees and breasts have thick, hard pads, and upon these, which are hairless, the animal can kneel or lie down without injuring the skin.

There are no horns, and the animal can close its nostrils at will.

The hump is almost entirely composed of fat, and forms a reserve of food which the animal uses in times of need. It is observed that as the camel crosses the sandy deserts, and suffers from fatigue and privation, the hump diminishes and nearly vanishes altogether. It can then only be restored by a long course of good feeding.

When an Arab is about to set out on a desert journey, he pays great attention to the humps of his camels.

The idea that the dromedary has two humps, and the

camel one, is a mistake. The camel and the dromedary in Arabia have each only one hump, and the two animals are alike, except that the dromedary is of higher breed—the difference between them being the same as that between a racehorse and a hack.

The two-humped beast is neither an Arab dromedary nor an Arab camel. It belongs to the Persian breed, and is called the Bactrian camel.

The stomach, like that of the cow, consists of four divisions; the third, however, is reduced to a mere passage. The paunch is furnished with large cells, which the camel fills when it has access to water, and then uses this water as occasion requires. A large camel will take five or six quarts of water into its stomach, and will exist for as many days without needing to drink, although meanwhile eating very hard food, even pieces of dry wood occasionally.

The pace.—When going at a good pace, a loaded camel takes only about thirty-eight strides a minute, and these measure about seven feet each. This means only three miles an hour, and generally the pace is considerably less than this. The swiftest dromedary may go ten miles an hour.

Character.—It is a great mistake to speak of the camel as 'docile' or 'good-tempered.' He is stupid and often spiteful. That he is also revengeful the following example will serve to illustrate. It is recorded in Palgrave's *Journey through Arabia.* A lad of about fourteen had conducted a large camel, laden with wood, from a village in the plain of Ba'albec to another village at half an hour's distance or so. As the animal loitered, the boy struck it repeatedly and harder than it seems to have thought he had a right to do. But not finding the occasion favourable for taking immediate quits, it waited its time; nor was

that time long in coming. A few days later, the boy had to reconduct the beast, but unladen, to his own village. When they were about half-way on the road, and at some distance from any habitation, the camel suddenly stopped, looked round to see that no one was near, and then made a step forward, seized the unlucky boy's head in its mouth, and lifting him up in the air, flung him down again, with the upper part of his skull completely torn off, and his brains scattered on the ground. Having thus satisfied its revenge, the brute quietly resumed its pace, as though nothing were the matter, until some men who had observed the whole, although unfortunately at too great a distance to be able to afford timely help, came up and killed it.

Value to man:

1. As a beast of burden, it is most important.

2. It also supplies food and clothing to its owner. The milk is sometimes kept until sour, in which state it is preferred by the Arabs.

3. The flesh is seldom eaten—only on festive occasions, and times of great necessity.

(For an account of the cooking of camel's flesh under the latter circumstances, see Palgrave's *Journey through Arabia*, vol. i. p. 27.)

4. The long hair of the camel is spun into a coarse thread, and woven into cloth.

THE ELEPHANT.

Description.—Two of the front teeth of the upper jaw grow to a great length and form **tusks**.

The nose is prolonged into a trunk which is movable in every direction, and is very sensitive. The nostrils are

placed at the end of the trunk, between a finger-like extremity.

The ear is large and flat.

There is only a scanty covering of hair.

The feet have five toes; but these are only partly shown by the divisions of the hoof. The feet are provided with a thick pad of skin, forming the palms or soles.

(See Huxley's *Anatomy of Vertebrated Animals.*)

Use of the trunk.—The trunk can not only be turned in every direction, but can be lengthened or contracted. The finger-like extremity enables the animal to lift from the ground small objects, to untie knots, and to grasp firmly. With its trunk the elephant collects food, liquid as well as solid. He cannot apply his mouth to the food, and it has therefore to be introduced by the trunk. This member is consequently so invaluable that if the elephant is attacked, he keeps it raised as high in the air as possible, and if it chances to get injured, he becomes wild with rage and terror. It is never used as a weapon of offence except to throw articles at any objects which he dislikes.

Food.—This consists of grasses, herbs, and roots. To obtain the last, having found their situation by his sense of smell, he turns up the ground with his tusks in the manner of a hog; in this way causing whole acres to appear as if recently ploughed.

He also feeds largely on shoots or smaller branches of certain trees. The elephant consumes an enormous quantity of food, passing the greater part of both day and night in feeding. The amount of green fodder a tame full-grown animal will eat in a day has been found to be about 800 lbs.

Though water is necessary to the elephant, he does not seem to require such a constant supply as most other animals. In places where persecuted, he passes the day in

the forest, far distant from river or fountain; and every night, if dry, or only every second or third night, if cool and cloudy, he marches to the water, which he usually disturbs before drinking, takes his fill, and retraces his steps to the forest.

Locomotion.—The elephant has a mode of walking which is strikingly different from that of any other quadruped. This walk is its only pace—it can be increased to a fast shuffle of fifteen miles an hour for a short distance; but an elephant can neither trot, canter, nor gallop. It is, besides, incapable of jumping. A ditch seven feet wide is impassable to an elephant, although the step of a large animal in full stride is about six feet and a half.

The elephant is a first-rate swimmer, and on cold nights, when fording water, he curls up his trunk and tail to keep them from being wetted.

Herding of wild elephants.—In India, elephants usually go in herds of fifty or more. The females, with their young, go first, and the males follow leisurely. They seldom stay more than a day or two at the same place. They rest during the middle hours of the night as well as of the day. When large herds are in localities where fodder is not very plentiful, they divide into parties of from ten to twenty; these remain separate, although within two or three miles of each other.

Elephants can make use of a great variety of sounds to express their wants and feelings. Thus, when rushing upon an enemy, an elephant 'trumpets' shrilly; but when angry by itself, it makes a hoarse grumbling through the throat. Pleasure is expressed by a continued low squeaking through the trunk, or by a purring sound from the throat. They sometimes rap the end of the trunk sharply upon the ground, so causing the air to be quickly driven out. This

produces a sharp sound like that made by the rapid doubling of a large sheet of tin, and is done when the animal is alarmed, or when it wishes to frighten an intruder.

Elephant-catching.—Elephants are usually captured by one of the following methods:

1. Driving into inclosures.
2. Hunting with trained female elephants.
3. Pitfalls.
4. Noosing from trained elephants' backs.

The first method is the only one for the capture of whole herds, the others being for single ones.

A hunting-party is formed of men trained to the work. These, with a good number of tame elephants, proceed in December to the forest. As soon as a herd is found, the hunters are halted, and while one half is sent off to the right, the other half is marched to the left, so as to surround the herd. A man is stationed at about every fifty yards as a guard. A thin fence of split bamboos is then run up in a few hours all round the ring, and watch is kept. The animals are not seen in the daytime, and if they approach during the night, they are driven back by shouts and guns. The men cook their food, of which they have a supply, at their posts, and sometimes have to remain there for a week or more. Meanwhile a strong inclosure or pound is built inside, and the approach to it being funnel-shaped, the elephants are, when everything is ready, driven into it. The tame elephants are now brought up with a rider on the neck of each. These tame elephants secure the wild ones by separating them one by one, and the men slip to the ground and tie the hind-legs of the elephants thus separated from one another. A rope is also put round each captive's neck, and another to one hind-leg, and they are led out

and kept until they are sufficiently submissive to be removed.

(See *Wild Beasts of India*, by G. P. Sanderson, chap. vii.)

Where found.—Asiatic elephants are found in India from the Himalayas to the extreme south; and in Burmah, Siam, and Ceylon.

In Africa they are found throughout all the more central parts as far north as Abyssinia.

Indian and African elephants differ as to:

1. *Ears.*—The African elephant having ears of different shape and much larger size than the Indian.

2. *Head.*—The forehead of the Indian elephant is perpendicular—a depression occurring just above the root of the trunk. That of the African elephant is convex from the commencement of the trunk to the back of the skull.

3. *Back.*—That of the Indian elephant is exceedingly convex, while the back of the African is exactly the reverse.

4. *Height.*—The African elephant stands higher than the Indian by a foot or more.

5. *Teeth.*—Those of the African elephant contain less plates than those of the Indian. Both sexes of the African are provided with tusks, while of the Indian only the males are 'tuskers.'

(See *The Lion and the Elephant*, by C. J. Anderson.)

Value to man.—In India the elephant is used as a beast of burden, and for sporting purposes. Fixed upon his back is a strong howdah, seated within which the sportsman goes forth in pursuit of tigers and other large game. In other parts of the East the elephant is employed in moving, drawing, or carrying logs of wood in the neighbourhood of docks and sawmills. The reasoning powers of the animal, whilst engaged in this occupation, are marvellous.

THE LION.

Description.—The colour of the lion is generally a yellowish or reddish brown. The tail is terminated by a tuft of long hairs. The male is furnished with a mane, which can be erected at pleasure. Each of the fore-feet has five claws, and each of the hind-feet four claws. They are extremely long and powerful, and much curved. They can be drawn back into a sheath inclosed in the skin that covers the paws.

In each jaw there are six strong and exceedingly sharp teeth. The tongue is rough, being covered with little elevations or *papillæ*, having their points directed backwards.

The huge eyebrows and fierce looks, together with the formidable fangs, give this animal a terrible appearance when enraged. He is possessed of piercing eyesight, and his hearing is very acute, but the sense of smell does not appear to be so keen.

The length of the South African lion from the nose to the end of the tail is from 11 to 12 feet, and its height to top of shoulder about 3½ feet. The weight of such a beast is about 500 or 600 lbs.

Strength.—The strength of the lion is enormous. A case is recorded of a lion breaking the back of a large ox while it was yet alive. One traveller says that he saw a lion in Cape Colony take a heifer in his mouth, and although the legs trailed on the ground, he carried it off as a cat would a rat, and leaped a broad ditch without any difficulty.

Pace.—Usually the lion walks, and although apparently at a somewhat slow pace, yet from the great length of his body, he gets over a good deal of ground in a short time.

He has been known to travel forty-five miles in the course of a night. Sometimes he trots; but when he gallops or bounds along, he moves at great speed.

Mode of getting food.—The lurking-place of the lion is generally near a spring, or by the side of a river, where he can surprise such animals as come to drink. Here he lies, crouching in some thicket, until his prey approaches, when with a sudden leap he seizes the animal. He either feeds on it where it fell, or removes it to the thicket. After he has satisfied his hunger for the time, he guards the remainder of the carcass day and night until he has devoured the whole. The lion usually catches his prey during the night, for the eyes of the lion are like those of the cat, suited for seeing in a dim light. A single stroke of the lion's paw is sufficient to kill most animals. Sir Samuel Baker, speaking of the unfortunate death by this means of one of his hunting companions, says: 'Great difficulty was experienced in extracting the claws of the animal, which had penetrated the skull of the unfortunate man.'

Roar of the lion.—The roar of the lion has been likened to distant thunder. The Arabs of North Africa call it *rad*, or thunder. The roars are deep-toned, and repeated five or six times in quick succession, increasing in loudness until the third or fourth, when the voice dies away in low muffled sounds. Lions roar loudest on cold frosty nights, and especially when two or three troops of strange lions approach a fountain to drink at the same time. The natives of South Africa are said to be able to distinguish between the roar of a hungry lion and that of one who has fed. Dr Moffat confirms this. In one of his wanderings, when retiring at night to rest, a lion was heard to roar near at hand. The natives who accompanied the missionary

listened for a moment or two, and then said: 'There is no danger; he has eaten, and is going to sleep.' They were right. When the lion is hungry, his roar is dull and stifled; but when he is satisfied, the roar is louder.

(See *The Lion and the Elephant*, by C. J. Anderson.)

Where the lion is found.—In Africa, from the Cape of Good Hope to the shores of the Mediterranean. In Asia, it is found in India, and parts of Turkey and Persia. It has disappeared from various countries where it was once found, as from Egypt, Palestine, and the whole of Europe. Lions' bones have been found in the gravel of the Jordan; and some travellers who visited Palestine in the twelfth century, say that lions were then in the coverts of the Jordan banks. Lions still occur in the Euphrates valley, and in the jungles near the rivers in Babylonia.

(See *Natural History of the Ancients*, by Rev. W. Houghton.)

THE TIGER.

General description.—Dark stripes occur across the body on a bright, tawny, yellow ground. This marking extends to the head and tail. The under parts of the chest and throat are, like the long hair which is on each side of the face, almost white. As with the lion, the legs are of nearly equal size. The hind-feet have four toes each, while the fore-feet have five. The claws are strong and curved like sickles, and can be extended from their sheaths, or withdrawn at pleasure. In hunting, if a tiger is hit, the hunters can find out if his wound is mortal or not by an examination of the marks on the ground left by the tiger's feet. If the injury is one which will soon cause death, the talons are protruded, and the ground torn up by them.

Full-grown tigers measure about ten feet from nose to tip of tail, and a well-fed animal of this length weighs three hundredweight or more.

Habits.—Though the tiger is a true cat, it is not nearly so good a climber as our domestic puss. Claw-marks of tigers are, however, often to be seen in the soft bark of trees, sometimes at thirteen feet from the ground. The tiger is a good swimmer, and has been reported to have had the audacity even to board a vessel. He swims high in the water, and in this way affords a good mark to the sportsman.

The tiger's powers of springing are not so great as the size of the animal would seem to warrant, for it has been observed to ford rather than jump channels of eighteen feet. Tigers are easily startled by any unlooked-for event. 'A youngster, eight years of age, while tending sheep, had formed his little black blanket into a bag and swung it, filled with reeds, on his back. While stooping among the bushes collecting more reeds, a tiger, taking him for a sheep, seized him from behind, or rather seized the bag. The boy fell over; and the astonished tiger, not knowing what to make of the bag of grass, bolted at once.'

(See this and other curiosities of tiger-life in *Wild Beasts of India*, by Sanderson.)

Tiger cubs are handsome little beasts, and very good-tempered. In order to be tamed they need to be taken very young, at about the age of a month. It would seem that tame tigers are not the treacherous savage creatures they are often represented to be. The distinguished sportsman from whom the above quotation is taken, says that he had a tame tiger of considerable size that used to be loose in his bedroom at night; and although he pillowed and thumped it when it jumped on his bed after he had fallen asleep, it never showed any ill-temper.

Where found.—The tiger is a native of South Asia, being found only in Hindustan, Siam, Cochin-China, Java, and Sumatra.

Mode of seizing its prey.—Tigers have been divided into three classes according to their prey:

1. Those which live upon cattle—**cattle-lifters.**
2. Those which live upon game alone—**game-killers.**
3. Those which frequently live upon human beings—**man-eaters.**

The tiger kills cattle in the following way: He slinks up under cover of long grass or bushes towards where cattle are feeding. Having sprung on his victim, he clutches its fore-quarters with his paws, seizes the throat in his jaws from underneath, and turns it upwards and over, by this means breaking the creature's neck. Cattle sometimes stand and stare at the tiger in stupid astonishment, and owing to this, a bold tiger may kill several.

If he does not intend immediately to feed, he leaves the spot, and returns a little after sunset, drags the carcass to some retired spot, and commences his meal.

After or during his meal, he drinks largely, often walking belly deep into water.

Methods of hunting and killing the tiger:

1. Hunting with a line of elephants—the sportsman shooting from the elephant's back.
2. Hunting with men called 'beaters,' where the jungle is too close for elephants. These by shouts drive the tiger in the direction of the sportsman.
3. Surrounding the tiger with nets, and shouting from the outside, either from elephant-back or on foot.
4. Watching for the return of a tiger to the animal he has killed, or to a dead animal placed there on purpose. A sort of platform is erected in a tree, and upon this the

sportsman lies and watches, often for hours, until the near approach of the beast enables him to get a shot.

5. Poison, spring-guns, pit-falls, and traps are also used, chiefly against the man-eating tigers.

THE DOG.

Kinds of dogs :

1. Dogs used for field-sports.
   (*a*) Those that hunt by sight, and kill, as greyhound, deerhound, and lurcher.
   (*b*) Those that hunt by scent, and kill, as bloodhound, foxhound, and harrier.
   (*c*) Those that hunt by scent, and do not kill, but indicate the whereabouts of the game, for the advantage of the sportsman, as setter and pointer.
   (*d*) Those that recover the game after it is shot, as spaniel and retriever.
2. Dogs useful to man in other work than field-sports.
   (*a*) Those that assist man in his work, as collie and Eskimo dog.
   (*b*) Those that watch and defend life and property, as bulldog, mastiff, St Bernard, and Newfoundland.
   (*c*) Those useful in destroying vermin, as terrier.
3. House and toy dogs, as King Charles spaniel, pug, Pomeranian, and poodle.

Age, &c.—The dog is born with its eyes closed; they do not become opened until the tenth or twelfth day. The teeth begin to change about the fourth month. The dog reaches his full growth at the age of two years, and seldom lives more than fifteen years.

Memory.—The late Dr Darwin gives an instance of excel-

lent memory in one of his dogs. 'I had a dog who was savage and averse to all strangers, and I purposely tried his memory, after an absence of five years and two days. I went near the stable where he lived, and shouted to him in my old manner; he showed no joy, but instantly followed me out walking, and obeyed me exactly as if I had parted with him only half an hour before.'

Reasoning power.—The following case is quoted by Dr Darwin: 'Two partridges were shot at once, one being killed, the other wounded; the latter ran away, and was caught by the retriever, who, on her return, came across the dead bird; she stopped, evidently greatly puzzled, and after one or two trials, finding she could not take it up without permitting the escape of the wounded bird, she considered a moment, then deliberately killed it by giving it a severe crunch, and afterwards brought away both together. This dog had never been known to injure a bird before.' This showed decided reasoning powers on the part of the retriever.

Sympathy.—The following instances also are told by Dr Darwin: 'I have myself seen a dog, who never passed a cat who lay sick in a basket, and who was a great friend of his, without giving her a few licks with his tongue, the surest sign of kind feeling in a dog.'

'I saw a person pretending to beat a lady, who had a very timid little dog on her lap. The little creature instantly jumped away; but after the pretended beating was over, he was most persevering in his attempts to lick his mistress's face, and to comfort her.'

The Newfoundland dog:

1. **Appearance.**—The head is very broad, and nearly flat on the top. It has a considerable brow over the eye, often rising three-quarters of an inch from the line of the nose.

The nose is wide in all directions; moderately square at the end, with open nostrils.

The eyes are small, and rather deeply set.

The ears are not large, and are covered with short hairs on all but the edges, where the hair is longer.

The neck is rather short; the chest is capacious, and round rather than flat.

The legs are very bony and straight, and well clothed with muscle.

The feet are large and wide, with thin soles. The toes are flat, and hence this dog soon becomes footsore on road-work, and cannot accompany a carriage or a horse at a fast pace.

The colour is black in the pure bred dog. There is often a white star on the breast. The coat is shaggy, and so thick and oily that it takes some time for water to reach the skin through it.

(See *British Dogs*, by H. Dalziell.)

2. **Habits.**—This dog is never so happy as when dabbling in water, salt or fresh. He is an excellent swimmer, and has great courage. There are innumerable instances on record of his having rescued human beings from drowning. By means of this dog's love of water, and his natural instinct to bring to shore any floating object, he may be educated to be of great service to man. For this purpose, at certain 'dog shows,' such tests as the following have been given:

(1) Courage displayed in jumping into the water from a height, to recover the effigy of a man.

(2) Intelligence and speed in bringing a boat to shore.

(3) Carrying a rope from shore to a boat, in which not his master, but a stranger is seated.

(4) Diving after sunken objects.

He is a good-tempered creature, and rarely shows anger at the treatment he sometimes receives from much smaller dogs;

and, although in some instances subjected to great hardships and privations, he is remarkably faithful in his attachment to mankind.

THE CAT.

General appearance.—Cats are black, white, tabby, sandy, tortoise-shell, dun, gray, and what is called blue. The gray cat is very rare. It is really a tabby without the black stripes, except two large stripes over the fore-legs.

Black cats usually have eyes of a clear yellow colour.

White cats have eyes of either a blue or greenish-yellow colour. Those with blue eyes are often partially deaf.

The tortoise-shell cat is generally female; the male of this kind is rusty red.

The blue or Carthusian cat has long soft hair of a dark grayish-blue tint, with black lips, and black soles to the paws.

The Persian cat is remarkable for its great size, and for the delicacy and length of its hair.

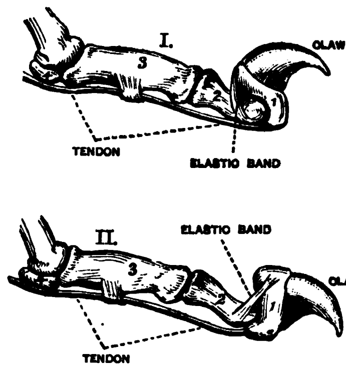
Tailless cats are found in the Isle of Man, in the Crimea, and in some other places.

The cat's whiskers are really large hairs, the roots of which are well provided with nerves and blood-vessels.

The claws.—There are five claws to each fore-paw, and four to each hind-paw. These claws are placed around the end of the last bone of each toe, as may be seen from the accompanying figures.

From the last bone to the last bone but one, in each toe, there passes an elastic band which keeps the claw back at ordinary times. When, however, the claw is to be protruded, it is drawn downwards by a tendon, which is a sort of string attached by one of its ends to a muscle, and by the other to a bone.

Teeth.—The kitten's first set of teeth begins to appear when it is between two and three weeks old, and by the end of the sixth week twenty-six teeth are cut. The teeth of this first set begin to fall out after the seventh month, and the second set of teeth appears in their places. When the cat is fully grown, she has thirty teeth—sixteen in the upper jaw, fourteen in the lower. Of these, the most prominent, as in all the carnivora, are the pointed curved teeth—one on each side of each jaw—which are called the canines. These, and the claws, are used by the cat in seizing and destroying its prey.



Bones of one of the Toes of a Fore-paw: I., with the claw drawn back; II., with the claw protruded; 1, 2, 3, 4, bones of the toe.

Food.—Though birds and animals smaller than itself form the cat's natural food, it shows a great liking for food which, in a wild state, it can rarely if ever get; for example, cow's milk and fish.

Like other carnivorous animals which seek their prey at night, the cat's eyes are each furnished with a lining of a brilliantly golden-yellow colour. It is this lining which gives the eye that light appearance when looked at in the dark, and which is produced by reflecting the light. This 'internal reflection' is supposed to aid the animal in seeing in a dim light.

Habits:

1. *Pace.*—The cat's usual pace is either walking or leaping. It does not often run unless pursued or alarmed. It can, when driven to it, swim, although it dislikes a wetting.

It can so turn in falling, as nearly always to alight safely upon its feet.

2. *Sounds.*—Cats have certain sounds to express their feelings. Besides the hideous yells which they give forth at night, they often, by gently mewing, make their wants known, and when pleased, express their satisfaction by 'purring.'

Rage and fear can be manifested both by sounds and gestures, as may be often enough seen at the approach of a strange dog.

3. *Sense of direction.*—Cats have a remarkable power of finding their way home by ways they may have never before traversed. When a dog returns home from a distance, the usual explanation is that he finds his way by the power of smell—having, as it were, a recollection of the smells he has passed, just as we find our way by recollecting the sights we have seen. But the cat's power of smell is not so keen, and the ability the animal has of making its way back again, seems due to a 'sense of direction' which it possesses—like that which enables a traveller, though constantly changing his path, to keep moving in the right direction.

(See also *The Cat*, by St George Mivart.)

4. *Love for young.*—Cats are very often devotedly attached to their young. Some time ago, a fire took place at a music hall in London, and the stage was badly burned. A cat with her kittens had their home behind this stage. When the fire broke out, the cat was not on the spot; but she returned while the fire was raging, and in a moment seemed to realise the danger threatened to her young, for,

dashing through the flames, she succeeded in bring out two of her kittens. Then, remembering there was still another behind the burning stage, and prompted by her natural instinct to save her young, the poor cat once more leaped through the fire; but this time it was to return no more. Her body was found after the fire was extinguished, dreadfully burnt and disfigured. No human being could exhibit greater devotion than this!

THE WHALE.

It is not a fish.—Although much like fish in external appearance and habits, whales differ from them in two important respects:

1. Whales breathe air by means of lungs. Fishes breathe water by means of gills. If a whale were prevented from coming to the surface to breathe, it would be drowned.

2. They are warm-blooded, and bring forth and suckle their young in the same manner as do quadrupeds.

Different kinds of whales:

1. **Toothless whales**, of which the chief are:

   (*a*) Greenland whale.
   (*b*) Hump-back whale.
   (*c*) Piked whale.

2.. **Sperm whales.**

Whales are found most abundantly in the frozen seas of Greenland, in Davis's Strait, Baffin's Bay, Hudson's Bay, and along some parts of the northern shores of both Asia and America. They sometimes visit the British coast; but in the Pacific and Atlantic Oceans they are found in considerable numbers.

Description of the Greenland whale.—It reaches a length of from forty to sixty feet. Nearly one-third of this length is made up of head, so that the eye, which is small, looks as if it were placed in the middle of the body. The skin is smooth and hairless, and beneath it is a thick covering of oily fat called **blubber**. The fore-feet look like fins, but they have bones similar in number and arrangement to those of quadrupeds. There are no hind-limbs. The principal swimming organ is the tail, which is often twenty to twenty-five feet in breadth. The neck is extremely short. The nostrils or 'blow-holes' are at the top of the head. There are no external ears.

(See Nicholson's *Zoology*.)

Feeding.—The mouth is enormously capacious, large enough indeed, in some cases, when open, to contain a boat full of men. The jaws carry no teeth. Across the mouth, springing from the roof, are plates of that horny substance known as whalebone. There are sometimes as many as 300 of these plates on each side of the mouth. The free edges of the plates are frayed out into a fringe of bristles.

The whale's mode of feeding is to swim rapidly, mouth open, just below the surface of the water. The enormous quantity of water thus taken into the mouth is not swallowed, but escapes by the sides when the mouth is closed. The shoals of small animals upon which the whale lives are meanwhile entangled and retained in the mouth by the fibrous edges of the plates.

Spouting.—When the whale rises to the surface of the water, he blows or spouts through each nostril a jet of something which looks like water. It is a mistake to suppose that the animal spouts water from his inside; the jet is really caused by the vapour contained in the breath being suddenly condensed by the coldness of the atmo-

sphere. If the whale begins to blow before his nostril is actually at the surface of the water, a certain quantity of spray may be driven up with the air. Whales usually remain at the surface, to breathe, about two minutes, during which they blow eight or nine times. They then descend for five or ten minutes, although when feeding, they may remain under for a considerable time.

Movements.—The usual rate at which whales swim seldom exceeds four miles an hour. The greatest speed may be eight or ten, but is never kept up for long. They can ascend with such rapidity as to leap quite out of the water, and they sometimes dive head foremost and beat the water with their tails until the sea is lashed into foam. When struck, whales have been known occasionally to descend to a perpendicular depth of a mile, and with such force that they have broken their jaw-bones by dashing against the bottom.

Mode of capture.—The whale is very affectionate towards its young, and this is sometimes taken advantage of in order to entice the parent animal into the snares of the whaler. The young whale, although not of much value itself, is struck in order that the mother may come to its assistance, and this she readily does. She rises to the surface of the water with it, encourages it to swim off, helping it to do so by taking it under her fin, and she seldom deserts it while life lasts. Meanwhile, the whalers get many opportunities for attacking the mother. This is done with harpoon and lance. The harpoon has an arrow-shaped head, which prevents it from being withdrawn when once forced into the fat. The lance used is an iron spear about six feet long, with a very sharp head of steel. As soon as the whale is struck, she plunges directly downwards, drawing out at the same time with great rapidity the line

which is attached to the harpoon. While this takes place, great care is required on the part of the whalers, for if the line runs foul and cannot be cleared on the instant, it will draw the boat under water. The whale may not reappear for half an hour. As soon as she is seen, the boats make for her again, and more harpoons and lances are hurled at the animal before she can descend again. This is repeated until at length the poor brute dies of exhaustion caused by loss of blood and prolonged submersion. Formerly, the harpoon was thrown by a man placed at the bow of the boat; nowadays it is propelled by a large gun made expressly for the purpose.

Uses of various parts of body:

1. The blubber yields an oil which, in polar regions, is consumed, as is also the flesh.
2. The skin, when properly prepared, is, although quite black, cut up into little blocks and eaten. It is said to have an agreeable flavour, not unlike that of the cocoa-nut.
3. The whalebone or mouth-plates are used for a variety of purposes; for example, riding-whips, stiff brushes, &c.

THE EAGLE.

Its form and structure are suited for rapid and prolonged flight.—The body is covered with feathers well adapted to protect the creature from cold and moisture. The wings are furnished with muscles of such power as to strike the air with great force, and thus to impel the body forward with astonishing rapidity. The tail acts as a rudder by which the course can be directed at pleasure.

The internal structure, too, is similarly adapted to the

mode of locomotion. The lungs communicate with cavities in the breast, abdomen, and even in the interior of the bones. This not only gives lightness to the whole body, but also keeps the blood supplied with that large amount of air which rapid flying makes necessary.

The bill is hooked towards its extremity, and forms a formidable weapon; hence birds of prey like the eagle hold the same rank among birds as the carnivora do among quadrupeds.

It consists of two mandibles or jaws, upper and lower; the former being fixed and immovable, and covered at its base by a kind of skin called the **cere**. The nostrils are oval and open.

The eyes have, besides the ordinary upper and lower eyelids, a third covering, which is pearly white, and more or less transparent. It is placed on the inner side of the eye, and has a special muscular apparatus, by which it can be drawn over the front of the eye like a curtain, and which enables the bird to gaze at light which would dazzle other creatures.

Principal species of eagles:

1. **The imperial eagle.**—This is the largest known, and inhabits the high mountains of the middle of Europe.

2. **The golden eagle** measures from tip to tip more than 6 feet, and weighs over 12 lbs. The general colour is a deep brown, mixed with tawny on head and neck. It is found in various parts of Europe, and sometimes in North America.

3. **The great eagle of Guiana** is provided with terrible beak and claws. It has long plumes, which form a black tuft on the back of the head, and which can be raised at will. It is very powerful, and is said to have killed men by a blow of its beak.

4. **The bald eagle** is the most distinguished of the North American species, and is the adopted emblem of the country.

Character of the bald eagle.—Benjamin Franklin thought that the eagle was not a fitting representative of the United States, because of its bad character. The bird does not get its living honestly. Too lazy to fish for itself, it waits until the fishing-hawk has secured some prey, and then pursues and seizes it. Moreover, this eagle is a great coward, for the little king-bird, no bigger than a sparrow, attacks and boldly drives him out of the district. He is also described as ferocious and tyrannical.

Haunts and habits.—The bald eagle is fond of the neighbourhood of the sea, and of the shores and cliffs along the great rivers and lakes of North America. He is found in considerable numbers at the falls of Niagara. He is very fond of fish, but feeds also on the flesh of deer, bears, squirrels, and other animals. There are well-authenticated stories of his having attempted to carry off children. (*History of Birds*, by Bishop Stanley.) Dr Darwin quotes an instance of an eagle seizing a young monkey, which, by clinging to a branch, was not at once carried off. It cried loudly for assistance, whereupon the other monkeys of the troop, with much uproar, rushed to the rescue, surrounded the eagle, and pulled out so many feathers that he had not only to relinquish his prey, but to struggle to escape.

The nest and young.—The nest is made of sticks, clods of grass, and pieces of moss. In the case of the bald eagle, it is usually on a lofty tree in a swamp or morass. The eggs are two or three in number, and of a greenish-white colour. In about four weeks the young are hatched. The eaglets, when they make their appearance, are covered

with a reddish down, and their beaks and claws are of a very disproportionate length. Few birds provide more abundantly for their young than does the bald eagle. He brings such large quantities of fish daily to the nest, that the putrid smell of the superfluous supply of food may be distinguished for several hundred yards.

(See also *The Bird World*, by W. H. D. Adams, pp. 119–123.)

The eagle as an emblem.—As the standard of an army, the eagle was first used by the Persians. The Tuscans once sent to the Romans as an attribute of royalty a sceptre with an eagle of ivory, and from that time the eagle became one of the principal emblems of the Roman republic, and it was retained afterwards by the emperors. Eagles were carried for a long time, as the standard of the legions, on a long staff. Napoleon selected the eagle for his banner. It was of metal, seated with wings folded, gilt, and elevated on a long staff. The eagle of the United States stands with outspread wings, guarding a shield below him, upon which are the stripes and stars. A double-headed eagle, too, has often been chosen as an emblem.

THE OSTRICH.

General description.—It has a small head, with a short, broad, and flattened beak; a long neck and a strong body, with wings incapable of flight. Its thighs are extremely muscular, and its feet are provided with two toes of unequal length, and have pads or cushions forming soles. The inner of the two toes is much the larger, and is clawed; the outer toe is small and clawless.

Young ostriches are of a mottled dark brown and

yellowish plumage; but when the birds are full-grown, these colours change to black and white respectively, and in the females to dusky gray. The feathers, which are so valuable when taken from the wings and tail, have the quill exactly in the centre; while in other birds, it is a little to one side of the feather, causing the webs on each side to be of unequal width.

The ostrich has often been called the 'camel-bird,' because of its resemblance to that quadruped. Both hold their heads very much forward, with long necks stretched out. The long legs of the camel are all near together, while the two legs of the ostrich are wide apart; and the result is, that when a line of these birds is seen in the distance, they look much like a string of camels.

(See Palgrave's *Journey through Central and Eastern Arabia*, vol i., p. 43.)

Where found.—Ostriches are found throughout Africa, from Southern Algeria to Cape Colony, wherever there is open country. They are quite unfitted for woody and hilly districts, and they can live in parts where there is but little water. In Asia, the ostrich has been known from the earliest times in Syria, Arabia, and Mesopotamia. It was formerly an inhabitant of Central Asia and India.

Speed.—The ostrich runs with extraordinary speed, and can outstrip the fastest horse. The length of its stride, when bounding at full speed, varies from twenty-two to twenty-eight feet. Dr Livingstone was once able to count the steps of an ostrich who took thirty strides in ten seconds. This would give a speed of at least forty-five miles an hour if the length of each stride be taken as twenty-two feet.

The ostrich is able to travel an enormous distance. In the daytime, it takes no rest, and is often met with in

the hottest season far from any water, and where no green shrub or leaf is to be seen.

Food.—Seeds, berries, fruit, grass, leaves, lizards and snakes, beetles, locusts, and small birds are eaten; and with these, large quantities of stones, sand, grit, bones, and other hard substances are swallowed. It seems to make no selection as to its food, but to devour greedily whatever can be swallowed.

The stomach of an ostrich which died in the London Zoological Gardens a few years ago, was found to contain, amongst other things, a number of copper coins to the value of $9\frac{1}{2}$d.

Habits.—Ostriches live in herds or flocks, although these latter are not large. Sometimes, if food is scarce, they live in companies of four or five only.

In Senegal, during the hot season, the ostrich has been discovered to bathe frequently, but not to swim. The same has been noticed in the sea along the coast of Abyssinia, where they have been seen standing for hours up to their necks in water.

The cry of the ostrich is deep and full, something like the roar of a lion, but the young are said to utter no cry even when in pain.

The ostrich lays its eggs in a large nest scooped out of the sand. Several birds use the same nest, and take it in turns to sit upon the eggs during the night, leaving them to the heat of the sun during the day. Each hen lays about a dozen or twenty eggs, but she does not usually sit upon all. In about six weeks the young are hatched, and immediately run about, and quickly shift for themselves.

Uses to man:

1. *The eggs* are considered a delicacy by the natives, who generally cook them by setting them upright on a fire, and

stirring their contents round with a forked stick, which they insert in a hole in the end that is uppermost. Each egg weighs about 3 lbs., and is equal to about twenty-four ordinary fowl's eggs. In taking the eggs, the natives are careful not to touch any but those that are to be removed, as the ostrich would immediately discover it on her return, and leave the nest.

2. *The egg-shell*, because of its strength, is often used as a vessel for carrying water. Bush girls, and women of the wandering tribes, may be seen coming down to the fountains each carrying a net containing twelve or fifteen egg-shells with a hole at one end. These shells are filled with water, and the hole closed up tightly with grass.

(See Livingstone's *Travels in South Africa.*)

3. *The flesh* is considered wholesome and palatable. The wild birds' flesh is somewhat tough, but that of the tamed ones, which have been fed on clover and grain, is, when cooked, very good eating.

4. *The feathers.*—The finest in breadth, grace, and colour come from the Syrian desert, but they are rare. The Barbary feathers are very superior, and are therefore expensive.

The Egyptian feathers are those which are brought to Cairo from various countries lying east and south of Egypt, and partly from Arabia. At Cairo, they are tied with thick twine-rope into bundles, and sold by weight. These bundles are very often unfairly packed, a large portion being made up of mere rubbish.

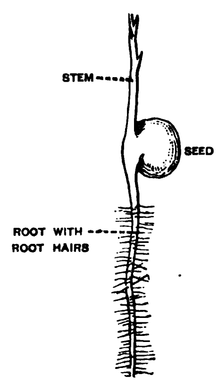
The Cape feathers come next in value to the Egyptian. They arrive in England sorted in different qualities and colours, and are sold by weight. An ostrich-feather merchant can at once perceive the difference between the feathers of a tame bird and those of a wild one. The former are stiffer and less graceful than the latter, besides being

lighter. From tame ostriches a few feathers are every now and then removed. To do this, the bird is driven into a yard, from which a narrow lane or pen leads out. The operator stands on a platform outside the pen, and catching the wing in one hand, plucks the ripe feathers with the other. The ostrich, while this is going on, never attempts to peck with the beak, but an attendant keeps the bird up to the place, and prevents it from turning. As only a few feathers are removed, the bird does not suffer much in consequence.

(See *Ostriches and Ostrich Farming*, by Mosenthal and Harting, pp. 185-232.)

THE PARTS OF PLANTS, AND THEIR USES.

If a seed, say of a pea or bean, be placed on some moist earth in a warm room, it soon begins to grow. One part grows down into the earth, while the other grows upwards. The descending part forms the **root**—the other gives rise to the **stem**.



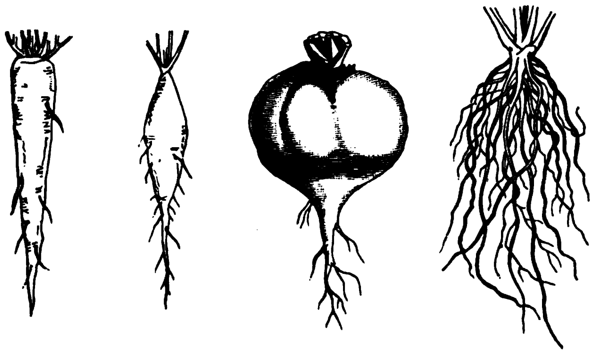
From the stem, buds and leaves spring.

Thus the chief parts of a plant are **root**, **stem**, and **leaves**.

The Root:

1. *Its form.*—(*a*) **Tap** root. When the part of the seed which grows downwards remains undivided, it forms a tap root, as in the carrot, radish, and turnip.

(*b*) **Fibrous** root. When a root divides into a number



Root of Carrot. Root of Radish. Root of Turnip. Root of Grass.

of slender rootlets, it is called fibrous, as in most grasses.

2. *Its structure.*—When a thin slice of the root of a plant is looked at with a microscope, it is found to be made up for the most part of little bags or sacs called **cells**. These are generally round, but often become altered in shape by pressure one against another.

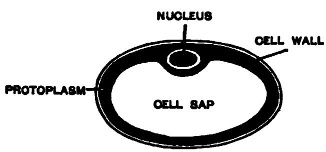


Diagram of a Vegetable Cell in section.

Each cell consists of—

(*a*) A **cell-wall**, which is firm and elastic.

(*b*) A soft semi-fluid substance lining this wall. This substance is called **protoplasm**; it is the living and most important part of the cell. Imbedded in this substance, and formed of the same material, but of darker appearance than the rest, is a roundish body, the **nucleus**.

(*c*) The **cell-sap**, which fills the cavity of the cell.

Springing from the root are root-fibres and root-hairs.

Root-fibres.—The tip of one of the smallest of these shows under the microscope (1) a sort of cap of flattened cells, covering the end called the **root-cap**, or **root-sheath**; (2) just under this cap, a mass of softer cells, forming the **growing-point**. New cells are constantly being formed by the growing-point, and then the root-fibre is pushed forwards. As this takes place, the flattened outside cells get worn off, and wither; but the growth of the new cells behind makes up for them.

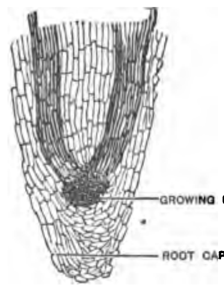
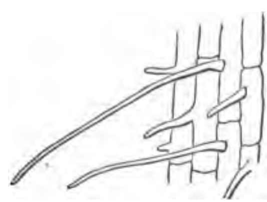


Diagram of tip of Root-fibre.

Root-hairs spring from the layer of cells which is outermost in the root. It is by means of the root-hairs that the root absorbs the water necessary for the plant's existence.



Root-hairs.

The Stem has upon it buds which grow into branches.

1. *Forms of stems.*—Those above ground:

(*a*) **Climbers.** Stems which are so weak that they trail on the ground; but being provided with tendrils, they cling for support to other plants, or to rocks or buildings; for example, the common pea creeper, vine, and ivy.

(*b*) **Twining stems**, which coil round other plants in a corkscrew fashion; for example, convolvulus and hop.

Those under ground:

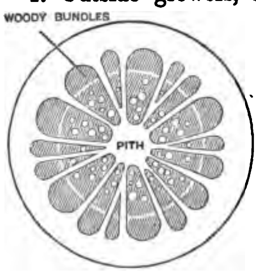
(*c*) **Bulb**, a very short stem, with crowded, overlapping leaves; for example, onion.

(*d*) **Rhizome**, or root-stock, a long underground stem; for example, iris or fern. The potato is a swelling called a **tuber** on such a stem. It is really the swollen extremity of an underground branch, its 'eyes' being 'leaf-buds.'

2. *Structure of stems.*—A thin slice of a young stem shows that there are three chief parts—namely, the **bark**, the **wood**, and the **pith**.

According to the way in which the woody part is arranged, plants are divided into:

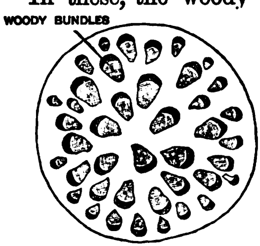
1. Outside growers, or **Exogens**, such as the oak, ash, beech, and any common forest trees.

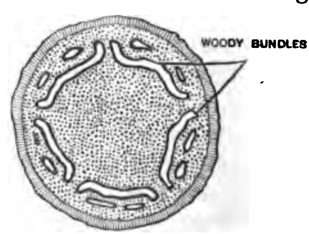


In these, the wood is arranged in rings of wedge-shaped bundles, and it increases in thickness by new wood being formed outside the wood already in the stem.

2. Inside growers, or **Endogens**, such as the palm, sugar-cane, butchers' broom.

In these, the woody bundles are scattered about among



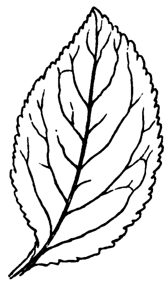


the softer cells, and are not arranged in a ring. These bundles do not increase in size after they are once formed.

3. Top-growers, or **Acrogens**, such as the tree-fern. A slice of its stem would show the wood arranged as in the last figure.

Leaves spring from buds upon the stem or branches.

Compound Leaf of the Rose.



Simple Leaf of the Apple.

Simple leaf with margin entire.

1. *Forms of leaves:*

(*a*) They may be simple or compound.

(*b*) Their edges may be either toothed or entire.

(*c*) They may or may not have a leaf-stalk. When leaves have no stalks, they are said to be **sessile**.

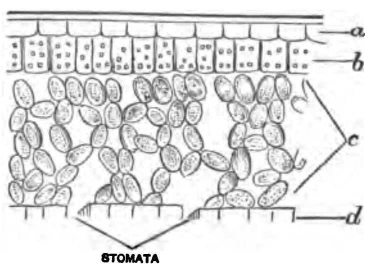
2. *Structure of a leaf.*—A leaf is made up of—

(*a*) A thin outer skin covering the upper side.

(*b*) A layer of close-packed cells.

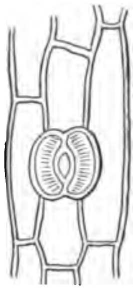
(*c*) Several layers of loosely packed cells.

(*d*) A thin outer skin covering the lower side.



In the skin, chiefly on the lower side, are many pores

or mouths called **stomata**, each bounded by two kidney-shaped **guard-cells**, as shown in the figure.



Food of Plants:

1. **Water**, in which various mineral substances are dissolved. These substances are made up chiefly of phosphorus, sulphur, potash, and iron.
2. **Carbonic acid gas.**
3. **Ammonia.**

Whence obtained:

1. **The liquid food.**—If any fresh plant be dried, the water which it contained at first is got rid of, and the plant becomes lighter. If this dried remainder be exposed to a red heat, it loses a great deal more weight, and only a little **ash**, which generally forms a fine white powder, is left. This ash is the material which the plant has derived from **the earth.** The earthy material is not always the same in amount. It varies in different plants, and it varies in the same plant when placed in different soil.

We know that the kind of soil in which a plant grows affects it, because:

(*a*) The colour of flowers may be altered by the addition of certain substances to the soil in which the plant is growing; for example, charcoal powder darkens the flowers of the dahlia and the rose. Carbonate of soda reddens the hyacinth.

(*b*) Woody bitter stems and roots have been changed in the course of years into large and juicy vegetables by being well fed in a rich soil. Thus, too, our cultivated fruits have been made to differ so much from the smaller wild ones from which they have been derived.

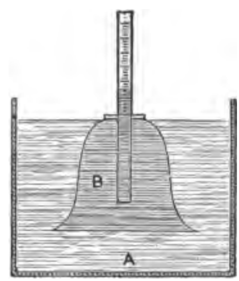
2. **The carbonic acid gas**, which is so important a part of the plant's food, is obtained from the air. Nearly the whole of the wood of the plant is built up by this invisible gas. Yet the carbonic acid gas forms but a small portion of the air. In a million gallons of air there are contained about four hundred gallons of this gas. But the amount altogether which is in the air is very large, and is quite sufficient to supply the vegetable world with all it needs. For the weight of the air resting on a square mile of land is about twenty-six millions of tons, and the weight of carbonic acid contained in the air would be more than thirteen thousand tons.

How obtained:

1. The earthy materials, with the water in which they are dissolved, are taken up by the delicate hairs which spring from the roots.

How does this liquid food pass through the cell-wall of these hairs, and afterwards rise in the root and stem of the plant?

An experiment helps us to understand this.



A bell-shaped glass has its mouth covered with a thin skin, and into its upper end is fitted a graduated tube. A coloured liquid containing sugar, gum, or salt dissolved in it is poured into the glass, and then the whole is placed in a vessel containing water. It is found after a time that the coloured liquid rises higher in the graduated tube. The water has therefore passed through the thin skin; but some of the coloured liquid has also passed out, and this is proved by both the colour and the taste which the water in the large vessel now has.

All this was at first thought to take place simply because the fluid on one side of the skin was thicker than that of the other side; but this has been shown to be not the whole explanation.

The character of the thicker fluid influences the rapidity of the action. If the substance dissolved in this fluid is, for instance, common salt, it passes much more readily through the skin than if it contained such a substance as gum.

The action takes place in this way: The skin being moistened with water, the fluid in B unites more or less readily with this water, which is therefore taken up by it. More water then takes the place of that already combined, and in this way the fluid in A (that is, water) gets through the skin. In a similar manner, although at a slower rate, the fluid in B finds its way into the water.

(See Marshall's *Physiology*, vol. ii. pp. 160–164.)

The walls of the cells of a plant act in much the same way as the thin skin in the experiment. They sometimes suck up so much liquid that they increase very greatly in thickness. This liquid passes into the sap, which by the same means rises from cell to cell.

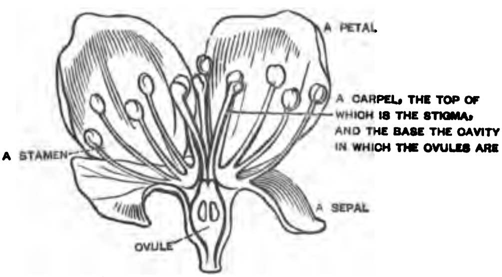
2. The carbonic acid gas passes through the small holes or **stomata** in the leaves, and so into the sap. As already described, the carbonic acid gas is decomposed in the leaf. A part of it is a gas called oxygen, which is set free and escapes into the air. The other part, called carbon, is retained by the plant for the formation of wood, starch, and the other compounds of plant-life.

THE APPLE.

Apple-blossom—Parts of the flower:

1. *The calyx.*—Resting upon the top of the flower-stalk is a cup, formed of five small green leaves united together. This cup is called the **calyx**, and the five leaves of which it is formed are called **sepals.**

2. *The corolla.*—If the flower is carefully sliced down lengthwise, we find that there are five separate pink or white leaves—the **petals**—forming an inner cup—the



Enlarged View of Apple-flower cut through lengthwise.

corolla. Each of the petals is placed in the space between the sepals.

3. *The stamens.*—Upon the calyx are arranged other leaves, although very much modified in shape and appearance. Each of these is called a **stamen,** and consists of a stalk, or **filament,** upon which is a head. When the head, or **anther,** is ripe, it opens, and there falls from it a powder made up of roundish grains, called **pollen grains.**

4. *Pistil.*—In the centre of the flower are *five* other leaves, unlike either sepals, petals, or stamens. These

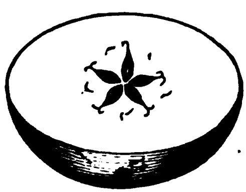
five leaves are called **carpels**, and together they form the **pistil**. Each carpel, when cut through lengthwise, is found to have at its base a cavity—the **ovary**—containing two little round bodies—the **ovules**—which afterwards become changed into seeds. The stalk of the carpel is called the **style**, and the top is the **stigma**. The stigma is usually covered with a soft sticky fluid to retain the pollen-grains that fall upon it.

Uses of the above parts.—The two outer sets of flower-leaves (namely, the sepals and petals) serve to protect the central and more important parts of the flower. These more important organs are the stamens and the pistil. When the pollen-grains fall upon the stigma, there grows out from each grain a long tube-like prolongation (the **pollen-tube**), which passes down the style of the carpel until it reaches the ovary. Along this tube there is conveyed a semi-fluid substance, which, when it reaches the ovule, fertilises it, and sets up that growth which changes the ovule into the seed.

(See figs. in Oliver's *Elementary Botany*, p. 23, and Sach's *Botany*, p. 33.)

Fruit—the apple:

1. *Description.*—At the top will be found the remains of the calyx, and sometimes a few withered stamens. At the base of the apple is the stalk. If we cut the fruit across, we see in the centre five cells, formed by the five carpels, each containing one or two seeds. These parts constitute the **core**. The remainder of the apple is really the fleshy swollen top of the flower-stalk.



Fruit of Apple cut across.

2. *Uses.*—Certain kinds of apples are chiefly cultivated for cider-making. The cider counties of England lie some-

what in the form of a horse-shoe round the Bristol Channel. The best are Worcester and Hereford, Somerset and Devon. The apples are gathered in September, and ground up in a mill into a kind of pulp, which is then pressed until all the juice is extracted. The juice is put into barrels, and allowed to ferment. About twenty-six bushels of apples yield a hogshead of cider, and a single acre of good orchard land will sometimes produce from 500 to 600 bushels of fruit.

Cider was the ordinary drink of our forefathers, and is still drunk largely in the west of England. In a new condition, it is not an intoxicating drink unless consumed in very large quantities. When old, it is considered agreeable and refreshing, and has sometimes been sold at a price equal to that paid for the choicer Rhenish wines.

The apple-tree flourishes best on hillsides, and in a deep rich soil. It cannot thrive in soil saturated with water, and on this account orchards should always be well drained.

The wood is very hard and tough, suitable for turning and cabinet-making. From the bark a yellow dye is extracted.

The tree grows to a considerable size, but rarely reaches the size and age occasionally attained by the pear. It is liable to injuries from an insect which is covered with a cotton-like down, and lives in the chinks of the bark, where it rapidly multiplies.

'Blight' is caused by certain caterpillars which, in early spring, attack and destroy the blossom.

Distribution and history.—The apple is found in temperate climates, and has been said to grow in the open air wherever the oak thrives. It is cultivated as far north

as the 60th degree of N. latitude, good apples being grown even in the Orkneys and Shetlands.

It is from the wild or crab apple that the cultivated varieties have been probably derived, and they came most likely from the East, as did most of our fruit-trees. The apple-tree is mentioned in early times, being among those enumerated by the prophet Joel (i. 12) as among the trees of Syria.

The fruit was known to both Greeks and Romans.

Of the apples now in common use in England, many of the better sorts have been introduced from the continent, and this is shown by the old French names which still cling to them.

Apples were, however, known in this country before the Conquest, and probably even before the Saxon invasion. Apple fritters were eaten in the middle ages. They were cooked with honey, and much resembled the pancakes of the present day.

'Costard-monger' is an old English term for the dealers in vegetables, because one of the principal things they sold was the large apple called the costard. This is the word which has come down to us as 'costermonger.'

THE ORANGE.

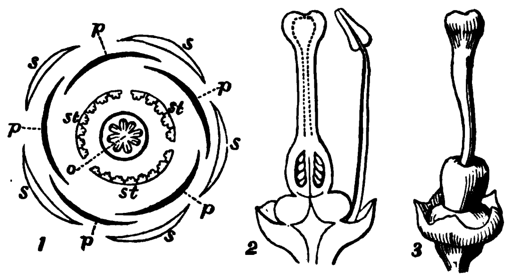
The orange-tree.—When full grown, it reaches the height of twenty-five feet. The trunk is of a delicate ash colour; the leaves of fine green, shining on the upper side, while the under side is slightly downy.

The flowers, which are in little bunches, are very graceful in form, and, in the sweet orange, of a delicate white colour.

They consist of—

1. A calyx made up of five sepals.

2. A corolla of five white petals.
3. Twenty stamens.
4. The pistil with many-celled ovary.



1. Diagram of the Orange Flower; 2. One stamen and the carpels sliced down; 3. Pistil by itself.

s, sepals; *p*, petals; *st*, stamens; *o*, ovary.

The fruit.—At the bottom of an orange may be seen either the calyx or the scar which the calyx has left. The flower-stalk is not sent to England attached to the fruit. At the top of the fruit is seen the scar left by the upper part of the pistil, which has withered and fallen off.

Thus the orange is the growth of the ovary only.

If we cut an orange across, we find it made up of a number of divisions separated from each other by thin partitions; and in the pulp contained by these divisions are embedded the seeds. Each cell or division corresponds to one of the carpels of which the pistil is composed.

The rind is of a spongy character, and contains very little juice or sap of any kind; but the outer surface is covered with little glands, in which an inflammable and scented oil is formed. This thick rind and the oil it contains preserve the fruit from the effects both of heat and cold, and from the attacks of insects.

Oranges intended for exportation are generally gathered green, for if allowed to ripen first, they spoil on the journey. Gathering for the British market generally takes place between October and December.

The orange-tree is remarkable for the enormous amount of fruit which it is capable of yielding, one tree sometimes producing 20,000 oranges.

How different kinds may be produced.—The soil in which the orange-tree is grown, as well as the climate, influences the character of the fruit greatly, and by differences in these conditions there have been produced very many varieties. This is illustrated by contrasting the oranges which are grown in Malta with those grown in St Michael's, one of the Azores.

Both these islands are small and exposed to sea-breezes. The winds, however, which blow over St Michael's have come across the Atlantic, and are on this account more temperate than the dry sultry winds which reach Malta from the African coast. The soil of the two islands is somewhat different; that of Malta being poorer and less fertile than that of St Michael's.

The Maltese orange is large, with a thick spongy rind, the pulp red and of a somewhat bitter taste. The St Michael's orange, on the other hand, is small, with a smooth thin rind, and a light-coloured pulp of a sweet delicious flavour.

History.—The Arabs seem to have been the first to introduce oranges into Europe.

They were brought from India probably; the sweet ones, which are now called China oranges, being introduced through Persia and Syria to Italy and South France; while the bitter ones were brought by way of Arabia and North Africa to Spain.

Oranges found now in St Michael's, and which are the

best in the European market, were introduced into that island by the Portuguese. The exact time when the orange was imported into England is not known, but it was probably in the sixteenth century. To Sir Walter Raleigh is attributed the credit of having introduced this fruit. It is said that Sir Francis Carew, who married Sir Walter's niece, planted the seeds, and that they produced the orange-trees at Beddington in Surrey, which were spoken of in 1695 as having been there for one hundred years. They were planted in the open ground, with a movable cover to protect them from cold weather.

Uses.—Besides being a delicious edible fruit:

1. The flowers yield an oil of fragrant odour, to the presence of which the scent of Eau de Cologne is chiefly due.
2. The small unripe fruits are used for flavouring the liqueur known as Curaçoa.
3. The rind of the sweet orange forms a good tonic.
4. The bitter orange is useful for making marmalade, while its rind forms candied orange-peel.

THE POTATO.

Description of the plant.—The potato plant grows to a height of about two feet. It has dark green leaves, and rather pretty flowers of a violet, bluish, reddish, or whitish colour. It belongs to an order of plants which includes several of a poisonous nature—for example, deadly nightshade, henbane, and tobacco.

Deadly nightshade or belladonna bears berries which are at first green, afterwards red, and eventually black. These berries present a general resemblance to black currants, and

have often caused the death of those who have eaten them in mistake for the latter fruit. It is a valuable plant medicinally. Henbane is a weed which grows in dry waste ground and roadsides in many parts of Great Britain. It has dingy, purple-veined yellow flowers. Its root is something like the parsnip in form, and is very poisonous. Tobacco yields, on distillation, an oil which is found to be a powerful poison.

(See Sowerby's *Useful Plants of Great Britain.*)

The tuber.—The potato, that is to say, the part eaten as food, is a 'tuber' or swollen portion of the underground branches. Each tuber being still a part of the stem, retains its buds, which are called 'eyes.'

Mode of planting.—To grow potatoes, the usual plan is to cut the roots in pieces, taking care that each piece contains a bud or eye, and then to plant these pieces in the earth in rows. If, instead of this method, the potato seeds be sown, tubers will be produced the third year, and a full crop the fourth.

The potato plant thrives best in a slightly sandy soil.

Varieties.—There are very many varieties of the potato, differing from one another in size, form, colour, and quality —each district often producing a peculiar variety, for example, 'Yorkshire Regents,' &c.

Enemies to the potato.—Several diseases attack potatoes. The most important is the one which, ever since 1845, has been called 'the potato disease.' It is caused by the growth of a fungus which begins in the leaves, and quickly extends to the stem and tubers. Upon the surface of the latter brown spots make their appearance, and penetrate its substance and so lead to decay. This disease spreads if the potato be kept. The sprouting of the buds of potatoes renders the tuber less wholesome as an

article of food. It ceases to be mealy when cooked, and acquires a sickly sweet taste.

(See *Foods*, by Dr Smith, pp. 200–201.)

Frost causes destruction of the cells of the potato, which is followed, when a thaw comes, by decomposition.

Composition of the potato.—Potatoes contain a large quantity of starch. In 100 lbs. of potatoes there are about 20 lbs. of starch. The amount of highly nourishing material contained in potatoes is, on the other hand, small. One pound of bread would contain as much of this material as 3½ lbs. of potatoes. On this account, therefore, it is necessary to eat a large quantity when potatoes form the sole food. It is, however, a common practice to take butter-milk or some such food with them, than to live upon potatoes alone. When floury, the potato is easily digested, taking from 2½ to 3½ hours for digestion; but when waxy, it is very trying to the stomach of weak persons.

Cooking of potatoes.—Boiling, steaming, baking, and frying are the usual methods. Heat causes certain changes to take place, which result in the separation of the cells of the potato from one another, and thus a mealy or floury condition is reached. If boiled, potatoes should be at once placed in hot water. The liquor in which potatoes have been boiled is of no use for food, and is said to contain substances which are injurious to health.

Uses.—Besides being used for food in the ordinary way:

1. They are largely used in making bread.

2. A kind of cheese is sometimes made from potatoes. They are reduced to a paste, and an equal quantity of curd, salt, and some other ingredients are added. The whole is mixed together and formed in moulds.

3. Starch is largely extracted from potatoes, by scraping them in water and well washing the pulp, after which the starch settles at the bottom as a thick sediment.

4. A spirit is distilled from potatoes.

5. A medicine is obtained from a decoction of the stem and flowers.

6. Even the seed-vessels are employed as a pickle, and are said, when properly prepared, to be superior to cucumbers.

History of distribution.—The potato came originally from South America, being brought to Europe from Quito by the Spaniards, in the sixteenth century. It was from North America that it was introduced into England and Ireland.

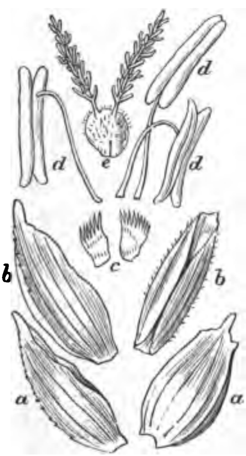
It was not thought much of at first. The potatoes of which we read in Shakspeare were 'sweet potatoes,' from a different plant altogether. The introduction of the potato into England by Sir Walter Raleigh was later and more successful. This vegetable was not, however, planted in the open fields until 1684, and for a good while after that date it was little esteemed as an article of food.

In hot climates, at the present day, the sweet potato, the artichoke, and similar plants take the place of the ordinary potato. In the Arctic regions, oil and animal foods are substitutes for it. Thus it is in the temperate portions of the globe that the potato forms a common article of food.

WHEAT.

Description of the flowers.—They are very different from such flowers as the apple or orange. They are destitute of flower-stalks, and arranged alternately in two rows along the top of the stem.

These flowers are called **spikelets**, and each consists of the parts shown in the figure below.



1. An outer pair of leaves (*a*).
2. An inner pair of leaves (*b*).
3. A pair of minute scales (*c*).
4. Three stamens (*d*).
5. The pistil (*e*).

Wheat.

(See also Oliver's *Elementary Botany*, pp. 52–53.)

The part eaten.—The seed is composed of a hard,

coloured external skin, and a central portion, which latter, when ground, yields flour.

The outside skin consists of an exceedingly dense and woody layer, which breaks up in the mill into the substance known as bran. The central white substance of the grain is composed largely of starch, but it contains other and more nutritious substances, such as albumen and gluten. It is the latter substance which renders flour such a suitable material for making into bread—the gluten itself being tenacious and readily solidified by heat.

Varieties of wheat.—There are several kinds of wheat—the differences between them being caused chiefly by differences in climate and soil. What is called 'hard wheat,' contains the most gluten. It is grown in warm countries, and upon fertile soils. The grain is hard throughout, is drier, and keeps better than other kinds. This is the wheat which is used in making vermicelli, macaroni, &c. 'Soft wheat' yields a whiter flour than this, is more easily ground, and contains less gluten.

According to the time of sowing, wheat may be divided into—

1. Spring wheat, which is more slender in the ear than the whiter kind, and is bearded; and

2. Winter wheat, which has no beard, and is sown in September or October.

Provided the soil be well prepared and dry, wheat does not suffer from extreme cold, especially if the surface be covered with snow.

When sown, each seed usually produces five or six stalks.

(For account of germination, see Hooker's *Botany Primer*, pp. 34–36.)

Enemies to wheat.—A disease called 'smut' or 'rust,' which is a kind of mildew, often attacks the grain, and a

few diseased grains will quickly infect a large quantity of seed corn. This disease renders the flour and bread unpleasant to the taste, but has not been shown to be hurtful.

In some places abroad, upon wheat there is found occasionally a fungus, which grows in such a way as to look like a spur, and is extremely poisonous.

Among wheat, if farmers are not careful, there may grow up grasses of a hurtful character, such, for instance, as darnel grass, the seeds of which are said to produce, when eaten, headache, delirium, paralysis, and even death.

A little insect called the weevil sometimes attacks wheat, and consumes the centre of the grain.

(See *Food and Dietetics*, by Dr Pavy, pp. 225–226.)

Distribution.—In all temperate climates wheat is grown; throughout the greater part of Europe; in all the provinces of China, in Syria, in Persia, North and South Africa, North America, and the extreme south of South America.

Uses.—Wheat is of great importance, because:

1. It may be produced abundantly and cheaply.
2. It is easily ground and refined.
3. It can be readily cooked.
4. It has a mild and agreeable flavour; and
5. Is pleasanter to the taste than maize, and more nourishing than rice.

Besides the wheat-grain which is useful for food, the straw of wheat, especially from dry chalky lands, is manufactured into hats. Leghorn hats are made from the straw of bearded wheat, grown in sandy soils between Florence and Leghorn in Italy. It does not grow above eighteen inches high, is pulled green, and is bleached like flax. The straws are not split, and the plait is on this account tougher and more durable.

THE AIR.

Air has weight.—Although we cannot see air, we know that we are surrounded by it, and that it fills those things which we generally speak of as being 'empty.' For we see what power the air has when it is in motion. It then drives round the heavy sails of the windmill, and forces along the heavily laden ships. Let a glass vessel be first weighed when full of air, and then again when the air has been pumped out. It will be found to have lost weight.

A cubic foot of air, as cold as water is when it freezes, weighs about 570 grains. A room, 10 feet each way, contains about 77 lbs. weight of air. Westminster Hall contains 75 tons.

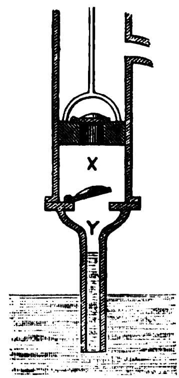
Pressure of the atmosphere.—The air which surrounds the earth is called the atmosphere. It is like a great ocean, and we live at the bottom of it. The height to which the air extends has never been certainly determined; but it must be fifty miles at least. So everything on the earth has to bear an enormous pressure. Suppose two hollow half-globes to be fitted together so as to form a globe, and supplied with a hole through which the air inside may be pumped out. It will be found that when this inside air is removed, the pressure of the atmosphere on the outside is so great that considerable force is required to separate the halves.

In one of the experiments of Otto von Guericke on this subject at Magdeburg, thirty horses were for a time unable to pull two large hemispheres apart when the air inside had been exhausted.

Every square inch has to bear a pressure of the air equal to nearly 15 lbs. It has been calculated that a man of the

ordinary size sustains a pressure of about 14 tons. Why is he not crushed? Because the air presses equally in all directions, upwards and on all sides, as well as downwards. Thus the air is bearing us up with just the same force as it is pressing us down. The air inside us too, counterbalances the pressure from without.

It is because of the pressure of the atmosphere that water rises in a pump. When we work the handle, we squeeze the air out of X. This brings the air out of Y also. At last there is little or no air in the pump. All this while the air outside is pressing on the water in the well, and so, because there is no air in X and Y to counterbalance this, the water rises higher and higher in the pump.



The pressure of the atmosphere varies constantly, daily and hourly; and these variations are shown by an instrument called the barometer.

Air is compressible.—The smallest particles of the air are so minute that no microscopes, however powerful, can enable us to see them. These particles float freely without touching each other. For this reason it is possible to squeeze air into a smaller space. If the outlet of a syringe be stopped, the air inside can be compressed. But as soon as the force by which the air is compressed is removed, the air again fills the space which it did at first.

All gases are therefore easily compressed; but this is not the case with liquids. Water can only be very slightly compressed, and to do this needs very great force. Because air can be squeezed together by pressure, the air around us is

denser or more compressed than it is at great heights. As we ascend a mountain, the pressure of the air becomes less and less, and thus the air becomes less dense. In this condition it is said to be *rarer*. This renders it unfit for us to breathe. At a height of eight miles no animal could live. Mr Glaisher once ascended in a balloon to 37,000 feet, or nearly 7 miles; but he had become insensible at 29,000 feet. Fortunately for him and his companion, the escape-valve had been opened before they actually became insensible. The gas which inflated the balloon being thus allowed to escape, enabled the balloon to descend into a less rare atmosphere.

Air expands by heat.—If a bladder only partially filled with air is placed in front of a fire, it soon appears full. The more it is heated, the more it will be stretched, for the air inside expands with the increased heat. It is as if the particles of the air were forced farther and farther apart as the temperature rises.

Composition of the atmosphere. {
- Oxygen.
- Nitrogen.
- Carbonic acid gas.
- Watery vapour.

1. *Oxygen* is a gas which, like the air itself, has no colour, taste or smell. Burning things are consumed more readily in it than in the air; and animals made to breathe only this gas become feverish and excited, and quickly die.

If a bottle full of oxygen is before us, we cannot see the gas, but we can show that it is present by placing in it a smouldering match. The wood will instantly burst into flame, and flare away rapidly. If a piece of bright steel be left in the air, it quickly tarnishes. The oxygen of the air is the cause of this. It unites with the iron and forms rust.

2. *Nitrogen* is in many ways unlike oxygen. A lighted candle or match put into it is extinguished. Animals made to breathe it soon die.

The atmosphere is made up chiefly of these two gases, oxygen and nitrogen, mixed together. There is nearly four times as much nitrogen as oxygen in the air. Thus, 100 gallons of air would contain about 79 gallons of nitrogen and 20 gallons of oxygen. The remaining gallon would be made up for the most part of carbonic acid and watery vapour.

3. *Carbonic acid* is the gas which gives a sparkling appearance to such drinks as ginger-beer and soda-water. It is without colour, but has a slightly sour taste. A light placed in this gas is at once put out, and animals cannot live in it. Wherever wood or coal is burned in the air or in oxygen, this gas is formed.

The air which we and all other animals breathe out contains more carbonic acid gas than the air which we take in does. So we are constantly adding carbonic acid gas to the air around us. But plants in the sunshine have the power of separating this gas into oxygen, which is set free and escapes into the air, and carbon, which remains to build up the plant. Plants are enabled to do this by the green colouring matter which is contained in their leaves.

As carbonic acid gas is one-half heavier than air, it accumulates if it is being formed in such places as the bottom of old wells and coal-mines. In the latter it forms the choke-damp which the miners so much dread.

(Read account of Poison Valley in Java. Johnston's *Chemistry of Common Life*, chapter i.)

4. *Watery vapour*—that is, the steam, visible or invisible, which rises from water exposed to the air. Its amount in the atmosphere differs at different times and in different

places. The higher the temperature of the air, the more water it can hold as vapour. When air is cooled, this vapour is changed into watery drops as mist or rain. When air has taken up as much moisture as it can hold, it is said to be saturated. The air of England is often saturated; while the driest air on the coast of the Red Sea has been found to contain only one-fifteenth of this quantity.

Uses of the atmosphere:

1. *Its oxygen.*—A continual supply of this gas is necessary to life. Through the lungs or gills of animals it passes into the blood, making it of a bright scarlet colour.

2. *Its nitrogen.*—This dilutes the oxygen, and prevents its too powerful action upon animals.

3. *Its carbonic acid.*—This is the food of the vegetable world. Plants need oxygen just as animals do; but unlike animals, they are able in the sunlight to use for *food* the very gas—carbonic acid—which animals cast out as poisonous.

RAIN.

What it is.—The atmosphere consists of certain gases and minute particles of dust, all of which are classed as dry air, and also of a variable quantity of **watery vapour.** This vapour is always rising from water in minute particles far too small to be visible, and being stored up between the atoms of air. The air can only hold a certain quantity of watery vapour, and when more is present, the vapour becomes condensed and visible, and is then called mist. This mist falling through the air, condenses into drops, which fall in the shape of rain. Rain, therefore, is condensed vapour.

How it is formed.—The heat of the sun changes water from sea, lake, river, and pond into vapour, just as the heat of a fire changes the water in a kettle into steam. This

vapour is stored up in the atmosphere, and is not seen. The warmer the air is, the more watery vapour it can hold. For every additional 27° F. the capacity of air to hold invisible vapour is doubled. When the air has as much watery vapour as it can hold, it is said to be **saturated**. If air which is saturated is lowered in temperature, it has to part with some of its watery vapour, and this is got rid of in the form of rain, hail, or snow. Fully saturated air at 32° F. contains about two grains of watery vapour in every cubic foot. Saturated air at 60° F. contains about six grains in each cubic foot, and saturated air at 80° F. contains about eleven grains. If, therefore, the fully saturated air with temperature of 80° is cooled down suddenly to 60°, about five grains of water are thrown down out of each cubic foot. Thus warm air drinks up as much invisible vapour as it can hold, floats it away on the wings of the wind, and then, when it reaches some colder place, throws a considerable portion of it down in actual droplets of water.

Clouds.—In rare cases, rain falls from a clear sky—the invisible vapour being suddenly condensed into exceedingly fine drops of rain. Generally, however, clouds are seen before rain. The water of which a cloud consists is in extremely small particles, as fine as any dust. Indeed these particles have been called by Professor Tyndall 'water-dust.' When watery vapour is condensed in this way near the surface of the earth, it forms a fog. There is very little real difference between a fog and a cloud. A fog is a cloud resting on the earth; and a cloud is a fog floating high in the air.

Clouds are of varied shapes :

1. The delicate white fleecy cloud which has the appearance of a hair or feather, and is very high above the surface of the earth, being sometimes as far as ten miles off, has been called **cirrus**, a Latin word meaning a curl. The water in such clouds has been thought to be frozen into minute

ice-particles, because of the effect these clouds have upon the light when they happen to come between us and the sun or moon.

2. A dense heap is sometimes formed by a cloud so large as to obscure the sun, and to cover the heavens. This often breaks up into many heavy clouds of similar form. Such a cloud has received the name of **cumulus**, a heap.

3. Sometimes the clouds are extended horizontally in sheets or layers, and to such the name **stratus** has been given, from the Latin word *stratum*, a bed.

Commonly enough, the clouds we see are not exactly like any of those named above, but appear to resemble each of them in part.

(See also 'Clouds' in *Modern Meteorology*, pp. 108–113.)

How the rainfall is measured.—For this purpose an instrument called a **rain-gauge** is used, consisting of a circular funnel for catching the rain, and a vessel for storing it. This instrument is placed in an exposed situation, and every morning, at a fixed time, the rain which has been collected during the preceding twenty-four hours is poured out of the collecting-can into the measure glass, and its amount noted. By the use of such an instrument as this, it is found that the yearly rainfall in London is about twenty-four inches. This means that if all the rain which falls in any level piece of ground in London during a year could be collected—none being lost by drying up, none running off the soil, and none soaking into it—it would form a layer covering that piece of ground to the depth of twenty-four inches. More than a hundred years ago it was found that rain-gauges near the ground collected more than those higher in the air. It seemed so strange that the nearer one went to the clouds the less rain was collected, that some experiments were made in 1766 by Dr Heberden, who had three

gauges placed, one in a garden near Westminster Abbey, one on the roof of a neighbouring house, and one on the central tower of the Abbey. The result was, that in the garden there fell twenty-two inches; on the roof of the house, eighteen inches; and on the Abbey tower, twelve inches.

The same has been observed in various places many times since, and the cause of the difference is still unknown. It is supposed to be due to the action of the wind.

(For description of rain-gauges, see *Modern Meteorology*, p. 138.)

The rainfall of certain districts:

1. *In England.*—The rainfall in the west of England is heavier than in the east. Thus while in London the yearly rainfall is about twenty-four inches, in Cornwall it amounts to forty inches. The wettest place in England is Seathwaite in Cumberland, where the average rainfall is 165 inches. The greater fall in the west of the British Islands is due to the presence of mountains. When a mass of moist air is carried by the wind against a mountain side, it ascends, and by so doing becomes chilled. Because chilled air cannot hold so much watery vapour as air of a higher temperature can, some of the vapour has to be discharged in the form of rain. For this reason it rains more often on that side of the mountain on which the wind commonly blows. The lee-side may have but little rain.

2. *In foreign countries.*—There are parts of the world where rain is so rare that they are called 'rainless districts.' Such are Upper Egypt, the Sahara, the desert of Gobi in Central Asia, and the coast of Peru. There are, on the other hand, places where the rainfall is twenty-four times as great as in London. The heaviest rainfall in the world (500 inches in nine months, and 524 in the year) has been recorded in the Khasi Hills, which are about 100 miles to the north-east of Calcutta.

Effects of rain:

1. Rain in descending washes the air, and takes from it impurities which, although unwholesome to man, are yet fitted to assist the growth of plants. Of these impurities some are gases, such as carbonic acid; some are inorganic particles, such as dust; and some are particles of animal or vegetable matter, as well as actually living germs. Thus the soil upon which the rain falls is not merely watered, but fertilised.

(See *Air and Rain*, by Dr Angus Smith, pp. 232–244.)

2. Because of the impurities which the rain takes with it in its descent through the air, it is enabled to work many changes upon rocks. In some cases by dissolving, perhaps, one of the ingredients, it causes the rock to crumble to pieces.

3. Another effect of rain, especially when heavy, is to remove an enormous amount of sand and mud to places of lower level.

(See Geikie's *Text-Book of Geology*, pp. 329–343.)

ICE AND SNOW.

The lightness of ice.—Ice floats on the surface of water. What is the cause of this?

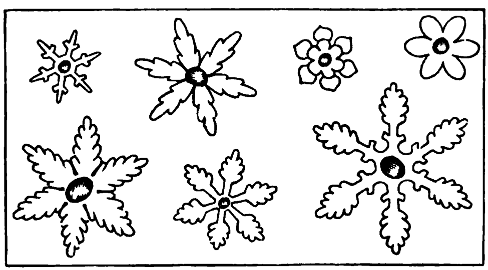
1. Let a glass flask be tightly corked, and through the cork let a tube pass water-tight. Suppose the flask to be filled with water, which, to enable it to be better seen, is coloured blue. Now, if the flask be heated, we shall notice first of all a sinking of the water owing to the expansion of the glass, and then a steady rise, until the fluid trickles out of the tube. If the flask be next placed in a mixture of pounded ice and salt, the liquid sinks. This continues for some time. At last the shrinking of the water ceases, and

instead of getting any less in bulk, the water actually expands, and this it continues to do until it changes into ice. The point at which the water begins to move upwards again is $39\frac{1}{2}°$ F. The cause of the lightness of ice, therefore, is the expansion of the water just before freezing.

2. If the particles of a body be allowed free play, they will assume certain forms called **crystals**. Thus, sugar dissolved in water, and allowed to evaporate slowly, will form crystals of sugar-candy. Saltpetre dissolved in water yields large crystals. Chalk dissolved has yielded Iceland spar, a beautifully transparent crystal.

The diamond is crystallised carbon.

If a slab of ice be placed so that a beam of light, either from the sun or from a powerful lamp, passes through, it is melted. This melting does not take place equally every-



Specimens of 'Ice-flowers.'

where, but at certain points, every point being surrounded by beautiful liquid flowers with six leaves each. These are ice-crystals.

The central spot of each flower is an empty space or vacuum. Because ice floats on water, it must be, bulk for bulk, lighter than water, and this lightness is produced by the empty space inclosed by the flowers.

3. Every particle of a substance attracts its neighbours by gravitation; thus the moon is attracted by the earth, and both are attracted by the sun. Heating a body pushes its particles farther apart, and so weakens the effect of gravitation. But besides being attracted to one another by gravitation, the particles of a body are supposed to be attracted in another manner. Because they are similar to magnets, their ends or poles, as they are called, attract or repel each other according to the positions in which they are. So, when a liquid is cooled, the particles first approach each other by gravitation, and then, when they have been brought sufficiently near to one another, the 'polar forces' come into play. Certain points are by these means attracted, while others are repelled, and in this way new positions are taken up which require more space.

4. The force of this expansion is almost irresistible. Major Williams, during a severe winter in Quebec, filled an iron mortar with water, and closed it by driving into its muzzle a wooden plug. When the mortar was exposed to a temperature of 50° below freezing-point, the metal resisted the strain; but the plug gave way, and was projected 400 feet.

If water is prevented from expanding, its temperature may be lowered below 32° F. without freezing. Thus a hollow steel cylinder has been filled with water and chilled to 30° F. below freezing-point. The steel prevented the expansion of the water into ice, as was proved by the rattling of a bullet inside the cylinder when the latter was shaken. As soon, however, as the tap was opened and the pressure removed, the water was instantly changed into ice.

Purity.—Sea-water saturated with salt becomes fresh on freezing. The only salt particles are a few which may be entangled in the pores of the ice. They have no part in the structure of the crystal.

Sulphuric acid has a strong affinity for water, and is used for a drier; yet, if a mixture of sulphuric acid and water is frozen, the crystal formed is quite free from acidity.

Light is partly stopped and partly allowed to pass by ice. The part of the light which passes through the ice is found to possess the same heating properties as before. Thus lenses have been made of ice, and the transmitted light has kindled wood and gunpowder.

Regelation—that is, freezing anew.

If two slabs of ice are sawed from a block, and their flat surfaces brought in contact, they freeze together. If a number of fragments of ice are placed in a basin of water, and just allowed to touch, they freeze together. Chains of icebergs are sometimes formed thus in Arctic seas.

Snow is formed of small particles of ice. If greatly pressed, snow may be changed into a slab of ice.

If a mass of ice is crushed to pieces, and then squeezed by great pressure, it may be formed into a mass of quite different shape from the first.

By applying the pressure gently, the ice need not be broken, but can be made slowly to change its form.

Thus it is supposed that glaciers suit themselves to their channels, some being the shape of a sheaf—broad at each end and narrow in the middle.

Occurrence of ice in nature.

Glaciers.—1. *The source.*—Ice is formed by compression of snow. Upon the top of the mountain the quantity of snow that falls annually, exceeds that melted. Below, the supply is less than that melted. Between the two extremes, there is a line along which the supply is exactly equal to the waste. This is the **snow-line.**

2. *Movements.*—Proofs: (1) At foot of the final slope of Mont Blanc is a great crevasse, into which three guides

were swept by an avalanche in 1820. Forty years afterwards their remains were found, many miles farther down the mountain. (2) By observations of the movement of stakes driven into the glacier near the sides. The daily motion of the Mer de Glace was thus found to be from twenty to thirty-six inches in the quickest place.

a, b, c, d, e, Moraines.

3. *Moraines.*—These are heaps of stones and fragments of rocks carried along by the glacier. If the glacier remains single, there is a heap along each side. If two glaciers unite, there is a middle moraine also, formed by the two nearest of the side-moraines. The finer rubbish of the moraine sinks into the glacier as its surface is melted.

4. *Crevasses.*—Cracks or rents.

(1) Those which cross the glacier are caused by a sudden drop in the bed. If there is a rise after this, the crevasse may be re-united.

(2) *Marginal cracks,* not in the direction of the glacier, nor across it, but between, are caused by the quicker speed of the middle of the glacier.

(3) *Longitudinal cracks.*—When a glacier comes from a steep narrow cutting upon an almost level plain, the ice which has been heaped up has now room to expand, and the push from behind compels it to

do so. This causes the strain to be across the glacier, and therefore longitudinal rents are produced.

Icebergs.—*Source.*—Chiefly from the mountains in the colder regions of the earth. The hardened snows fall into the valleys and fill them with ice, and move downwards to the sea.

Undermined by the waves, the icebergs break away in vast masses. Some run aground on shores close by; others reach the ocean. The part underneath is melted by the sea, and the iceberg topples over and finally disappears, after having travelled sometimes 2000 miles. One was seen by Sir L. M'Clintock, 250 feet high, aground in water 500 feet deep, so that its total height must have been 750 feet.

Bergs generally carry masses of rock, which are deposited where the ice melts. This explains the occurrence in certain places that were once under the sea, of 'erratic blocks'—unlike the rocks of the district in which they are found.

RIVERS.

The source of a river.—Rivers are, directly or indirectly, fed by rain. A Roman writer, Pliny, speaking of the course of a river, begins by saying that although 'it springs from the earth, its origin is in heaven.' If rivers, however, were only dependent upon *direct* supplies of rain, they would disappear altogether during dry seasons. But some of the rain which falls sinks at once into the earth, and reappears as springs. It is because much of the water of rivers is derived from springs that rivers continue to flow even in very dry weather. Thus the little river Wandle, a tributary of the Thames, drains an area of fifty-one square miles of the Chalk Downs; and it has been

found that this chalk rock is so saturated that it can continue to supply the river with a large yield of water by its springs for eighteen months after any rain has fallen.

The sources, or first waters of a river, then, are usually **springs** which issue from the sides of hills or mountains. The water from these springs forms **brooks** or **rills**, and these, as they run down to places of lower level, unite to form **rivulets**. When several rivulets run together, a **river** is the result.

The land from which the water runs to form the river is called a **basin**. This name is given to it because it may be roughly represented by a trough or basin with three sloping sides—the hollow or lowest part being where the river runs.

The course of a river.—In a country where a river receives no tributaries, it grows smaller and smaller in volume as it moves onwards, until in a hot climate it entirely disappears. Taking the case of a large river supplied with tributaries, we find that it may be conveniently divided into three parts—upper, middle, and lower.

1. **The upper or mountain track** is where the river begins as a mere brook, and, uniting with numerous smaller torrents, dashes rapidly down in endless cascades, growing in volume constantly until it reaches a lower level.

(For an account of waterfalls, see Zornlin's *World of Waters*, pp. 244–263.)

2. **The middle or valley track** is where the river flows through lower hills, and is found at one time in a wide valley, and then in a dark gorge; at one time falling headlong in a cataract, and at another expanding into a

broad lake. This is the part of its course in which it receives the largest tributaries.

3. **The lower or plain track.** Here the river winds sluggishly, and perhaps at last divides into two or more branches as it approaches the sea, inclosing tracts of flat meadow or marsh. Finally, amid banks of mud and sand, it passes out into the great ocean.

In Europe, the Rhone, Rhine, and Danube; in Asia, the Ganges and Indus; in America, the Mississippi and the Amazon; and in Africa, the Nile, are examples of such a course.

Speed of rivers.—The speed at which a river flows is dependent upon the slope of its bed. The average rate of flow is much less than might be supposed. Even the speed at which a torrent flows is not more than eighteen or twenty miles per hour; and it has been calculated that the Thames, Tay, Clyde, and such rivers run at about one mile an hour only. The rate of flow of a river varies not only at different parts of its course, but also at different positions of the river across the same part. Thus the surface-water moves faster than that at the bottom, and the middle of the stream flows more rapidly than the sides. This may be tested by watching straws and other objects floating down the current. Friction against the bottom and sides of the channel of course retards the flow.

Work of rivers:

1. Rivers dissolve portions of the rocks through which they pass.

When rivers flow through granitic rocks, as most of the rivers in the Highlands of Scotland and in Wales do, the water is soft. But the water of the rivers which flow into the sea on the southern and eastern shores of England is hard. This hardness is due to substances which are *dissolved* in the

water. That is to say, the water may be perfectly clear and yet contain a large quantity of solid matter in solution. Thus the Thames carries past Kingston 19 grains of various solids dissolved in every gallon of water. This means that 1502 tons in every 24 hours, and 548,230 tons every year, are passing away to the sea in a form quite invisible to the eye. But the Thames is only one of the many rivers which dissolve rock-materials in this way. If we could take all the rivers of the world into the calculation, how great the amount would be! In the sea, these vast quantities of dissolved substances form the materials from which plants and shell-fish derive part of their nourishment.

(See *Physical Geology of Great Britain*, by A. C. Ramsay, pp. 254–264.)

2. Rivers carry along mud, sand, gravel, &c.

If a clean glass vessel be filled with a gallon or two of water from such a river as the Thames, and allowed to stand for some time, a muddy layer appears over the bottom, and the water becomes clearer. This muddy layer is formed of fine particles which were *floating* in the water. The size of the fragments which the river is able to carry along depends on the volume and speed of the river, as well as on the weight of the solid. A river moving at three inches per second will just begin to move fine clay. One moving at six inches will move fine sand; at twelve inches per second, fine gravel; at three feet per second (that is, only two miles an hour), pebbles of the size of an egg. The swiftest streams, however, are not always the muddiest. A good deal depends upon the hardness or softness of the rocks through which the river flows, and on the frequency with which the rain falls. If a great deal of rain falls in a very short time, the river may become a rolling current of mud, as do some of the rivers of India during the rainy season. In Livingstone's journeys through Equatorial Africa, he

came across rivers which seemed to consist of more sand than water.

3. Rivers form new land with the mud they carry.

The sediment, or mud, which is carried along by a river is dropped when the water is at rest; so that as soon as the motion of the river is checked, some of the floating mud begins to sink to the bottom. The land which is thus formed is called **alluvium.** Such land is deposited at several points in the course of a stream.

(*a*) At the foot of mountain slopes. The torrent in its headlong descent tears away large fragments of the mountain side; but on reaching more level ground, these coarse materials are dropped, and form a fan-shaped cone of boulders and shingle.

(*b*) In river-beds. Wherever the river makes a sharp bend, the water on the concave side has its motion checked, and there, accordingly, sediment is deposited.

(*c*) In lakes. This is well shown in the case of the Rhone, which rises in the Alps, and after a rapid course reaches the Lake of Geneva as a muddy and turbid river. At the lower end of the lake, the river issues forth as a clear stream. During its passage through the lake, therefore, the sediment which it carried is deposited on the bottom; and, accordingly, where the river enters the lake, land is being by this means slowly formed. Port Vallais, which was originally on the margin of the lake, is now two miles away from the lake; the intervening land having been formed through the filling up of what was lake by the mud brought down by the river.

(*d*) Deltas. Because a river, as it reaches the sea, usually slackens its speed, a deposit of sediment commonly takes place. This does not happen, however, if the coast-line on either side is lofty, and the water deep; or if the coast is swept by powerful tidal currents. The Nile has formed in

this way a large tract of land, which was called by the Greeks the Delta, because of its resemblance to the Greek letter Δ, with the point or apex directed towards the river, and the base fronting the sea. Although at first applied specially to the land at the mouth of the Nile, the name has come to be used for many other similar deposits, wherever found. A delta is formed by successive layers of the materials, both mineral and vegetable, that are brought down by the river, and, after these reach the surface of the water, also by the growth of vegetation. Large quantities of drift-wood are often carried down, and with bodies of animals, become buried in the delta.

Perhaps the greatest delta in the world is that of the Mississippi, which is forming at the rate of nearly 300 feet yearly.

Many of the rivers of Europe have formed deltas, although on a smaller scale. Thus the Rhine, Meuse, Sambre, Scheldt, and other rivers have formed what is now Holland and the Netherlands. The Rhone, Po, and Adige, with the Danube, are other examples. The Roman river, the 'yellow Tiber,' as it is called from the large amount of sediment which it carries, is forming land rapidly at its mouth. Ostia, which was the ancient harbour, is now three miles inland.

(See Huxley's *Physiography*, chap. ix.)

THE SEA.

Distribution and depth:

1. The sea covers about three-quarters of the surface of the globe. This enormous body of water has been divided into three great oceans—the Pacific, Indian, and Atlantic—connected by an ocean round the South Pole, called the

Antarctic; and another, and much smaller, around the North Pole, called the Arctic Ocean.

2. It has been found from recent soundings, especially those taken on board the *Challenger*, that few parts of the Atlantic are more than 3000 fathoms deep. The deepest sounding was taken about 100 miles north of the island of St Thomas. It gave 3875 fathoms, or nearly $4\frac{1}{2}$ miles. Generally, however, the Atlantic was found to have a depth of from 2 to $3\frac{1}{2}$ miles. The Pacific Ocean soundings in some places gave as much as 5 miles, but this great depth is unusual. Its average depth is like that of the Atlantic, about 3 miles.

3. The floor of the sea appears to form great plains, with lines of ridges similar to chains of hills or mountains on land. It is covered in most places by a layer of fine materials, formed of shells of minute animals, and the like.

Waves.—The sea is never quite at rest. Its surface is troubled with waves. These are produced by the wind. A gentle breeze curls the surface of the water into **ripples**. A strong gale or furious storm raises the surface into **waves**. Waves whose crests are torn off by the winds, and which tumble over in foam, are called **breakers**. These on rocks form constantly a mass of foam—the **surf**—which it is dangerous, if not impossible, to pass. The largest waves observed were some whose height was recorded as 43 feet. Waves of British seas probably do not exceed 8 or 10 feet, even on the west coast. Close to shore, however, they may be somewhat higher. Spray is often carried to the tops of cliffs in the north of Scotland. The windows of the lighthouse on Dunnet Head are sometimes broken by stones carried up the cliffs by the sheets of sea-water which deluge them.

The power of the waves is sufficient to move enormous blocks. Masses of rock weighing 20 tons each, have been

One part skirts the coast of Brazil; the oth
Gulf of Mexico, and when it issues thence,
Stream. (See Huxley's *Physiog*

Tides.—Besides waves and currents, the
ocean are in perpetual motion owing to the
are caused by the attraction of the sun a
great wave is thus raised, and the effects of t
through the ocean. Twice in every twenty-f
margin of the sea, on this account, rises an
height of the tide—that is to say, the differ
high water and low water—varies a good deal
figuration of the land. In deep bays, especial
are funnel-shaped, this difference is very gre
Chepstow the tide rises from 45 to 60 feet; an
of Fundy, on the coast of the United Sta
amounts to as much as 70 feet.

Destructive power of the sea.—The rai
detach portions of the cliffs, which no
within the reach of the waves, than they are
against the other so constantly, that they are
pebbles or grains of sand. Then, too, the falle
are carried by the waves, and dashed with so
against the base of the cliffs as to gradually was
away. By such means the sea is encroachin
land of our country—in some places, where th
soft, at a rapid rate; in other places, more slowl
Thus along the east coast of England, from F
Head to Kilnsea—a district called Holdernes
structive action of the sea has been so great that
ants of many towns, long ago built upon the
been forced to migrate landwards. The town of
where Henry IV. landed in 1399, has quite
the land on which it stood being now fairly ou

On the south side of the mouth of the Thames is the ruined church of the Reculvers, which was once at a considerable distance from the sea. Now the church is protected artificially, because it is a good landmark for sailors, otherwise it would have been washed away by the sea long ago.

On the south coast, too, as for instance in Hampshire, the footpath along the coast often ends suddenly on the edge of the cliff, and is made to start afresh inland.

The site of the ancient Saxon cathedral-church that preceded that of Chichester, is known to be far out at sea.

In parts where the rocks are formed of materials of unequal hardness, the softer rocks are wasted more quickly, and in this way bays, such, for instance, as St Bride's Bay in Pembrokeshire, have been made. All along the west coast of England, bays have been thus formed. They have been scooped out in the softer rocks by the sea, while the more solid rocks have wasted but very slowly, and consequently stand out now as bold headlands.

(See *Physical Geology of Great Britain*, by A. C. Ramsay.)

THE FARMER.

General description of the work.—A farm in England usually consists partly of arable or tilled land, and partly of pasture or grass-sown land. From both of these are raised articles of food—from arable land, food for men or cattle; from pasture land, food for cattle exclusively. The occupation of the farmer is to apply to these, severally, the tillage or dressing most suitable for raising from them the largest supply of food, and also to rear and tend cattle. The work on a farm, as regards the preparation of the soil, and the planting and gathering of its products, varies with every

season, and almost with every month of the year. In the late autumn or early winter, the farmer has to plough, harrow, and prepare his ground for sowing wheat. In early spring, he has to sow barley and oats; later on, his root crops, such as mangold-wurzel, carrots, turnips, and potatoes; beans, peas, vetches, and artificial grasses.

In summer time, he has the important duty of hay-making, and in early autumn, that of harvesting. Later on, he has to gather in his root crops, and so the year is filled up.

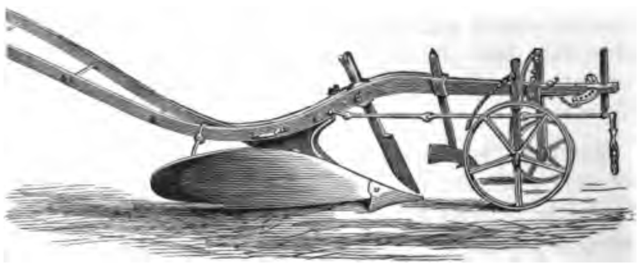
The attention to cattle is more constant, but still it varies with the seasons, more trouble being involved in winter time when the cattle are kept indoors than when they can be left entirely out of doors, in the pastures, and feed themselves.

Daily work.—In early morning, the horses have to be fed and groomed; the cows milked, and, if indoors, fed. The other animals have also to be attended to—the pigs, sheep, and poultry. After being fed, the horses are taken out to plough, or harrow, or to cart manure, &c.; the cattle are driven to the pasture, and the sheep are carefully inspected and tended by their shepherd. In the evening (and sometimes at mid-day) the cows have again to be milked and brought home, and the sheep again driven into their pens; the horses brought back from the plough, and groomed, and fed. Meanwhile the dairy operations, the making of butter and cheese, have been carried on within the house; and outside, according to the seasons, has been going on the preparation of the ground for the various crops mentioned below, or their planting, weeding, and hoeing, or their gathering and housing.

Implements of tillage the farmer uses.—Besides the spade, hoe, &c., the chief large implements which the farmer uses are:

1. The plough.
2. The cultivator or grubber.
3. The harrow.
4. The horse-hoe.
5. The clod-crusher and roller.
6. The drilling machine.

1. The **plough** was originally contrived to do the work of the spade. It consists of a ploughshare, or hollow angular block of iron for cutting through the soil. One part of

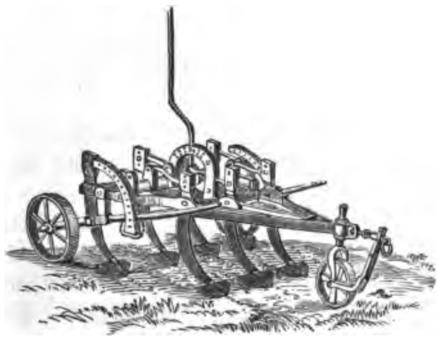


Ransom's Wheel-plough.

this share is straight, while the other is curved at the top hinder corner, so as to completely turn over the soil. The ploughshare is fastened to the beam, a long iron bar, somewhat curved, to one end of which are bolted long handles for the guidance of the plough, while at the other end is fixed a wheel, or wheels, on which it may rest as it is drawn along.

There are very many kinds of ploughs, but they are all on the same principle, although many of them have no wheels. Where the land is suitable, ploughing by means of steam-power is often resorted to. The ploughs in this case are drawn backwards and forwards by a stationary engine, and are provided with several shares, so that a number of furrows may be cut at the same time.

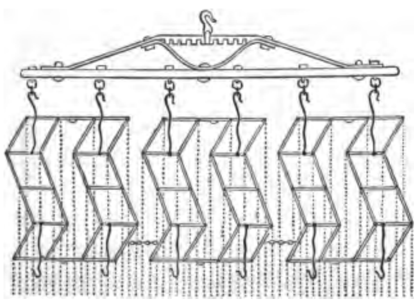
2. The **cultivator** or **grubber.**—This is used for stirring the land and freeing it of weeds. It consists of a frame into which are fixed teeth six to twelve inches long. These



Coleman's Cultivator.

teeth are curved forwards obliquely, and slant downwards, but they are prevented from entering the ground too far by the wheels which support the framework of the implement.

3. The **harrow** is an oblong iron frame into which teeth



Howards' Harrow (Iron).

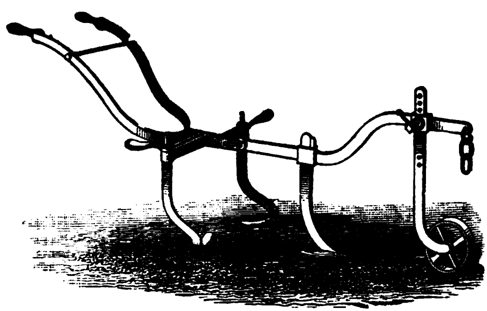
are fixed for the purpose of breaking up clods, and smoothing the surface. Most harrows are drawn cornerwise, by

which contrivance their teeth do not follow each other in rows, but scratch the surface more effectually. Some harrows are of zigzag form, and made in several frames fastened together by chains. The joints enable the harrow to adapt itself to irregularities of the soil, and render it very effective for bringing roots to the surface, and pulverising the land.

4. The **clod-crusher** is a cylinder furnished with knobs for the purpose of more effectually breaking up the clods. Sometimes the cylinder is divided into many pieces, all strung on an axle like a series of wheels with toothed edges, moving alongside of each other, each with independent action. The roller is a plain iron or stone cylinder, and is used not so much for breaking clods as for pressing the sown seed into the ground.

5. The **drilling machine.**—This is used for depositing the seed in equidistant rows. It consists usually of a frame on wheels carrying several hollow iron spikes, which scoop out a furrow into which the seed passes through the tube from a box placed at the top.

6. The **horse-hoe** consists of a framework into which is



Horse-Hoe.

fixed a hoe in front, and behind and on either side of it two

cutters or teeth curved inwards towards one another. The distance apart of these cutters may be adjusted to the width of the rows between which the implement is to be drawn. Its object is to cut through the weeds which have grown in the spaces between the rows of wheat, turnips, &c., and it can only be used where the seed has been sown with a drill.

Crops the farmer cultivates.—The farmer usually distinguishes three classes of crops:

1. Grain crops.
2. Fodder crops.
3. Root crops.

1. The **grain crops** cultivated in this country are chiefly wheat, barley, oats, and rye. Wheat, according to the kind, may be sown in the autumn or in the spring. The ground is prepared by manuring, ploughing, and harrowing. It is common to roll the crop in spring to consolidate the soil about the roots. Wheat is cut in early autumn. It is still cut in a primitive way with the old sickle in some parts of the south of England; but generally it is cut with the **reaping-machine**, one of the greatest of modern improvements. Self-binding reaping-machines, in which the wheat is bound by the machine, are now coming into use. In most cases the wheat is tied into sheaves, and dried on the land. It is finally carried to the farm-yard, and stacked ready for threshing. **Threshing** is usually done by machinery. The corn is fed into a pair of slowly-revolving fluted rollers of cast iron, by which it is presented to the action of a rapidly revolving drum, armed with four beaters or square spars of wood faced with iron. The rapid strokes of these beaters detach the grain from the ears, and throw the straw forward upon slowly-revolving rakes. In passing over the rakes, the loose grain is shaken out of the straw, and falls

through a grating into a winnowing machine, which separates the grain from the unthreshed ears, and gets rid of dust and broken straw.

A somewhat similar treatment is applied to the cultivation of the other grain crops—barley, oats, and rye.

2. **Fodder** or **green crops.**—These consist of the various kinds of grasses which are grown on the permanent pasture land of the farm, as well as of clover and ryegrass which form temporary pasture. Before these crops begin to grow, the land requires to be manured occasionally either with liquid farm-yard manure, or some artificial manure, as ground bones or guano. Sometimes land is laid down to grass for two or three years only, and this is called temporary pasture. A mixture of various grasses, such as clover and ryegrass, is sown in rotation with the other crops of the farm; and the pasture thus formed is either mown for hay or eaten off by sheep.

Haymaking.—This very important part of the farmer's occupation is carried on about the middle of summer. The grass is mown either by hand or by a mowing machine when most of the grasses are in flower. It is then shaken, and spread about the fields to dry in the sun as quickly as possible. When dry it is carted to some convenient place, and made into a stack which, when completed, is thatched. The hay is then left till it is required for the use of the cattle.

Ensilage.—A method of preserving grass without drying it in the sun has been introduced in recent years into this country. The green grass is put into an air-tight pit called a silo, and pressed down tightly. The pit is then closed and made air-tight, and when opened months afterwards, the fodder is found to be sweet and good, and will be readily eaten by cattle.

3. **Root crops.**—The principal root crops which the

farmer grows are turnips, mangold-wurzel, beet, carrots, parsnips, and potatoes.

Turnips are grown in rows wide apart to allow of the horse-hoe and cultivator being often passed between them, and they are singled out in the rows with the hand-hoe till they are ten or twelve inches apart.

Mangold-wurzel and *beetroot* are usually sown in April and gathered about October, and generally form food for the spring and early summer. They require a plentiful supply of manure, and deep cultivation is essential.

Carrot and *parsnip.*—The parsnip is not much grown as a field crop, but the carrot is extensively cultivated where the soil is suitable; and it is useful for fattening cattle and for feeding dairy cows.

They are sown in spring, and gathered in autumn, but the parsnip occupies the ground considerably longer than the carrot.

Potatoes.—The time of planting varies according to the kind, but is generally carried on in one of the early months of the year.

Potatoes are dug at different times from June to October. They form a very exhausting crop to the ground, which should be plentifully manured for their growth.

The cattle the farmer rears.—The cattle which the farmer rears are horses, oxen, cows, sheep, and pigs. Besides the rearing of cattle, the rearing of poultry is largely carried on in some farms.

Horses.—The common breeds used for farm-work are the Flemish and Black Draught, the Shire, the Clydesdale, and the Suffolk Punch.

The regular cart-horses are usually kept and fed in a stable. In summer time, however, they are sometimes allowed to run loose about the pastures. Besides hay, either whole or cut up into chaff, the food of horses con-

sists of some kind of grain, usually oats; in winter, sometimes roots, such as carrots, turnips, or potatoes, are given as food, and in summer green fodder such as clover.

Horses require to be kept in a well-ventilated stable. They should be kept clean, and always carefully groomed at least twice a day, in the morning before going to their work, and in the evening on their return from it.

Cattle.—The principal breeds are the Short-horns, Polled (or hornless) Aberdeen-Angus, Suffolks, Herefords, Devons, and Sussex.

Oxen are in some parts of England used for ploughing and drawing the wagon. They are, however, chiefly bred for fattening and sale for food. Cows are, of course, reared for the milk they produce; but when, from age or other reasons, their supply of milk becomes deficient, they too are fattened and sold to the butcher.

Whenever the weather is not too severe, cows are allowed to roam about the pastures and feed themselves. In winter time, and often at night, they are kept in the farm-yard.

Their food is chiefly grass and hay. When in the farm-yard, they are usually supplied with roots such as turnips, swedes, mangolds, &c. Milch cows require regular attention in being milked as well as fed. Cleanliness is beneficial to cattle as to all animals; and more care should be taken than is often done to keep their coats free from dirt, &c.

Sheep.—The chief varieties of sheep are the Southdowns, Shropshires, Oxfordshire Downs, Hampshires, Leicesters, Lincoln, Cotswold, Dorset, Cheviots, and the Blackfaced or Mountain Breed.

Sheep are allowed to roam over the downs and similar places to crop the short dry herbage. They are close croppers, and it is usual to retain a portion of the farm in pasture and allow them to graze over it.

(For an account of the management of pigs and poultry, see *Dairy, Pigs, and Poultry*, by R. S. Burn.)

THE CARPENTER AND JOINER.

What he does.—The carpenter's business consists in framing timbers together for the construction of roofs, floors, partitions, &c. The joiner has to *join* together the wooden finishings and decorations of buildings, such as floors and staircases, solid door and window frames, doors, chimney-pieces, &c. Very often, however, both branches of the work are carried on by one man, who is both carpenter and joiner.

The tools required:

1. The chief *cutting tools* are saws, planes, and chisels.

The saws used differ from one another in shape and in number of teeth.

In some, as for instance in the saw called the **ripper**, there are only eight teeth in three inches; while in the smallest, the **dovetail saw**, there are fifteen teeth to the inch. Then there are saws for cutting circular work and for cutting out small holes.

Planes are of different kinds. The **jack-plane**, which is about a foot and a half long, is used for removing the roughest surface of the wood. The **smoothing-plane** is small, and is used for cleaning off finished work. Chisels may vary in form. Some are used with the pressure of the hand merely, others are struck by the mallet. The ordinary carpenter's chisel is a flat piece of steel sharpened at one end and fitted with a handle. The **gouge** is a chisel with a curved cutter.

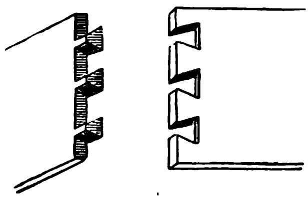
2. *Boring tools* are bradawl, gimlet, and stock-and-bit.

The **bradawl** consists of a pointed piece of steel ending in a flat edge like a chisel. It is more suitable for such soft substances as pine and leather than for hard woods as mahogany and oak.

The **gimlet** is used for hard woods such as teak, &c. It ends in a pointed screw which can be easily worked into the wood, while the lower part, being hollowed out, receives into the hollow the wood which is cut through. The gimlet has therefore to be removed every now and then in order to get rid of the wood thus collected. The **stock-and-bit** is formed of two parts, the handle, which is called the stock, and the pegs or bits of steel of various shapes which may be fitted into the bottom of the stock.

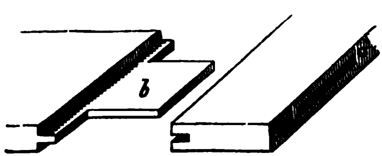
Other tools are the screw-driver, pincers, hammer, mallet, marking-gauge, hatchet, and adze; besides the straight-edge, the square, and the plumb-rule.

Description of some carpentering processes:



1. *Dove-tailing.* — Projecting wedge or *dove-tail* shaped pieces called **pins** are made to fit into similarly shaped **sockets**. Dove-tailing is extensively used for connecting boards at right or other angles, as in making boxes, drawers, &c. The common dove-tail joint is shown in the figure.

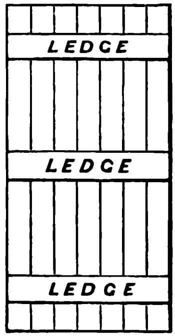
2. *Mortising.*—A projecting piece called **a tenon** is made to fit into a hole called a **mortise**. The figure shows the common form of mortise and tenon joint as generally used in making the frames of doors, shutters, and such pieces of joinery. When the tenon has been glued and driven home, it is usually clinched with thin wedges, driven into the edge of the mortise from the

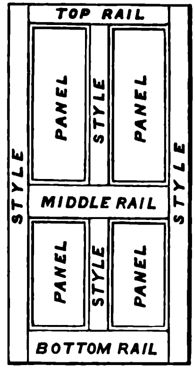


a, mortise; *b*, tenon.

outside. When the parts are dried and fixed, it becomes impossible for the tenon to be drawn out of place.

3. *Door-making.*—A door may be roughly made by putting together a number of boards, and screwing or nailing across them pieces of wood called ledges.





Such doors are used for cellars and for other common purposes. An ordinary room-door has its parts carefully joined together. The names given to the various parts are seen in the figure.

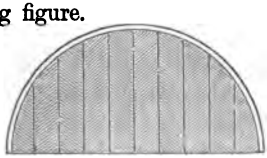
The styles and rails are mortised together, and the panels fit into grooves cut into the styles and rails.

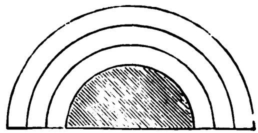
This kind of work is called **framed work.**

4. *Circular work*, or 'sweep work' as it is called, is performed by one or other of the following methods:

The wood may be steamed and bent into shape.

It may be glued up in thicknesses, and when dry, planed and covered with a thin veneer as shown in the accompanying figure.

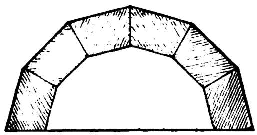




Or it may be in thin layers bent round and glued up in a mould, as represented in the second figure.

Hollow pillars, or cylinders, such as drums for machines,

&c., are built in sections like the staves of a cask (see figure), and afterwards turned on a lathe.



Or, lastly, a number of notches may be sawn on one side, by which means it may easily bend in that direction.

Kinds of wood used.—In joinery the woods most commonly used are oak, pine, mahogany, plane-tree, birch, beech, and sometimes lime-tree and poplar. Foreign oaks are preferable to British, as they contain no knots and are more easily worked.

The fir timber, which is of the most consequence to the carpenter and joiner, is principally obtained from the Baltic countries and North America. The chief kinds are called white pine, red pine, and yellow pine, and as they differ very much in toughness, smoothness of grain, and freedom from knots, the joiner finds in one or another of them wood suitable for almost every purpose.

The wood of the larch is also largely used. Lime-tree is valuable for carved work, and does not become worm-eaten.

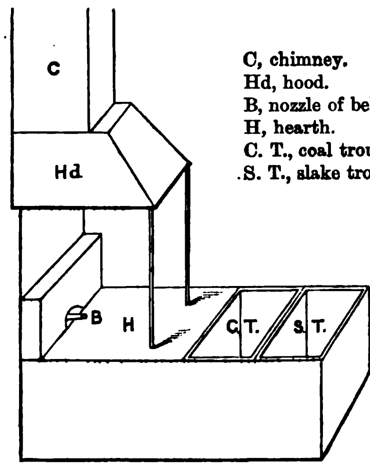
THE BLACKSMITH.

General.—The chief occupation of the blacksmith is shoeing horses, but he is also a maker of common chains, plough fittings, and wheel tires, as well as the repairer of the iron work of agricultural implements.

The blacksmith's forge.—The hearth is a brickwork trough raised to a convenient height above the floor of the smithy. The lower part of the chimney ends in a hood of iron which catches the smoke and guides it into the

chimney. At the back of the hearth is a thick iron plate, having in the centre an iron nozzle through which the blast from the bellows is driven.

The bellows may be worked by hand or by a treadle.



C, chimney.
Hd, hood.
B, nozzle of bellows.
H, hearth.
C. T., coal trough.
S. T., slake trough.

In front of the hearth are two iron troughs, one to contain coal, the other, called the slake trough, being filled with water.

The management of the fire.—Before lighting the fire, the used ashes are scraped out and removed. Some wood shavings are lighted, and upon these are placed cinders. The bellows are set to work, and a white smoke arises which soon gives place to flame. The work is now put into the fire, and coal is laid on and patted down with the shovel.

Use of the fire.—Iron must be brought to one or other of the following five degrees of heat in order to render it more pliable and malleable.

Black heat.
Low red heat.
Bright red heat.
White heat.
Welding heat—when the iron begins to burn with vivid sparks.

The hottest part of the fire is of course opposite the blast.

Iron is usually worked at a low red heat. When iron is raised to a welding heat, sand is usually sprinkled upon it. This forms a flux or fluid glass upon the iron, and protects it from the impurities of the fuel. It also removes the coating of dry scales which has been produced upon the iron by the high temperature. To weld together two pieces of iron, both should be raised by gradual heat to the same degree of temperature; and a little sand is then strewed on each piece, and the two pieces are held in position on the anvil by two workmen. Two other men now set to work with hammers until the two pieces of iron are completely joined. No coal-dust must be allowed to get on the surface to be welded together, otherwise the joint is spoiled.

Tools:

1. *The anvil* is usually a square block of wrought iron, the upper part or face being covered with hardened steel. It varies in weight from 100 to 500 lbs. It is generally set upon a large block of wood, to which it is secured by spikes or wedges. Cutlers, filemakers, and those who manufacture small articles of steel, place their anvils upon blocks of stone in order to secure a firm foundation and to prevent recoil. The blacksmith's anvil has projecting corner bases which are bolted down to the stock upon which it rests.

2. *The hammer* consists of a broad end or 'face' and a narrow end or 'pane,' with handle sometimes, as in the

cutler's hammer, nearer to the latter than the former. It ordinarily weighs 5 or 8 lbs. A heavy sledge-hammer weighs 12 or 15 lbs., and a swing sledge from 25 to 30 lbs. The latter is grasped by both hands at the extremity of the handle and swung at arm's length over the head. In this way it is made to give the heaviest blow of which a hand hammer is capable.

In ordinary light work the sledge-hammer is used 'up-hand,' that is, the right hand is slid up the handle towards the head as the tool is lifted, and slipped down again as it descends. When the smith swings the hammer in a circle between each blow, allowing his hands to slide down to the end of the handle, the action is called 'about sledge.'

3. *The tongs.*—The parts of the tongs by which the work is grasped are called the 'bits.' They are sometimes flat, as shown in the figure.

Blacksmith's Tongs.

They may be made to fit very close for thin work, or to stand open for more thick work.

The handles of the tongs are called the 'reins' or 'shanks,' and over these there is usually put a ring to keep hold upon the work.

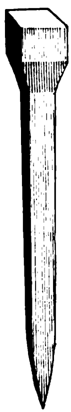
Tongs vary according to the form of the bits; thus the pincer-tongs have hollow half-round bits; others have crooked bits projecting in such a manner as to allow a rod or bar to pass down them; and hammer-tongs, which are used for holding punched work, are so formed that the bits enter the holes and hold firmly.

Shoeing.—Horse-shoes in ancient times seem to have been more in the form of a sock of leather or other material, than of an iron shoe nailed to the hoof.

An ordinary horse-shoe is a bent piece of iron varying in length from seven to fourteen inches. Nearly all round runs a groove, and in this are the nail holes, usually seven in number. At the toe there is a clip, and the heel is turned up to form what are called 'caulkers.'

When the blacksmith is about to shoe a horse, he first removes the old shoe and then rasps the hoof all round, at the same time removing any old pieces of nails there may be left. Usually some of the hoof has to be pared away, especially at the toe.

The shoe is now fitted, before nailing, in order that if it does not exactly suit the shape of the foot it may be altered.



The nails are of the shape represented in the figure.

They are generally pointed and sharpened just before using. Eight was the number of nails formerly put into every horse-shoe. Seven or even six are now considered sufficient if care is taken that the shoe exactly fits the foot. In nailing on the shoe, each nail must be put in the centre of the hole and driven home by three or four fair blows, care being taken to drive it towards the outside of the hoof, without touching the 'quick.' Horses' hoofs are often overpared, which causes much uneasiness, if not pain; and to remedy this the shoes are now being made of a better construction. One of these improved shoes is called the Charlier, after the inventor.

THE BRICKLAYER AND THE MASON.

The bricklayer.

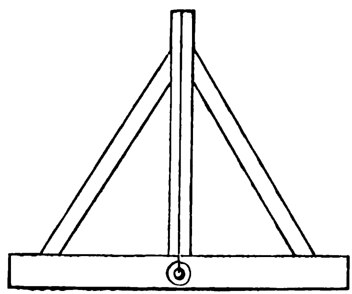
Nature of the work.—A bricklayer is not only engaged in doing all kinds of work in which bricks are used, but he is also employed in tiling and paving with bricks or tiles. In the country he is often a plasterer also.

Tools required.—The **trowel** to take up and spread the mortar, and occasionally to cut the bricks the required length.

The **tin-saw** for making cuts in bricks.

The **raker** for getting out the mortar from joints of old brickwork.

The crowbar, the pick-axe, the shovel, the square, and plumb-level.



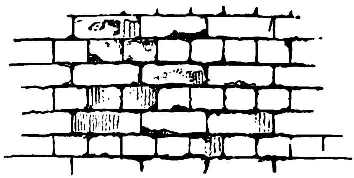
Bricklayer's Plumb-level.

The last-named tool consists of a flat horizontal piece of wood, upon which is fixed an upright piece, having at its centre a string carrying a ball of lead. When the flat piece of wood is resting upon anything perfectly level, the ball of lead hangs exactly in the centre of the hole which is in it.

Scaffolding.—Fir poles called **standards** are fixed in the ground or in barrels of earth. Horizontal bars called **ledgers** are placed parallel to the walls, and lashed to the standards. Pieces of wood called **putlogs** each rest the one end in a hole in the wall, the other on a ledger. On these putlogs the thick scaffold boards are placed upon which the bricklayer stands.

The bricklayer is supplied with bricks and mortar by a labourer who carries these materials in a hod, or more often raises them in a basket by a pulley.

Bond.—In bricklaying it is very important that no joint should be immediately above another in the next course.



Accordingly, the bricks are arranged so as to avoid this.

Bricks placed lengthwise in any work are called **stretchers**; those placed in a contrary direction being called **headers**. Bricks are often arranged in the manner shown in the figure—the courses being laid alternately with headers and stretchers. This is called English bond.

The mason.

Nature of work.—The mason is engaged in shaping the stones which are to be used in a building, and in setting them in their places in the work.

If the stone is valuable, such as marble, it comes to the mason's hands in large blocks. He then cuts these by means of a saw without teeth into slabs of the size he requires. As soon as a cut is made into the stone, the action of the saw is aided by sand, which is placed in a heap upon the stone, and is carried into the cut by the trickling of water.

Tools used.—The chief tools required by a mason are mallets and chisels. The mason's mallet is rounded, and has a handle only just long enough to be grasped firmly.

The smallest chisel used is one called **the point,** which is only a quarter of an inch broad at the cutting edge. The largest is the **broad tool,** which has an edge three and a half inches wide.

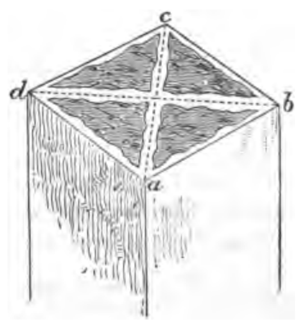
Besides mallet and chisels, the mason employs a **banker** or bench, on which he places the stones he is working, trowel, lines, plumb-rule, straight-edges, squares, bevels, and templets.

A **bevel** is formed by nailing two straight edges together at the angle to which the stone is to be worked.

A **templet** is a pattern for cutting a block to any particular shape.

Scaffolding.—Mason's scaffolding is for the most part double, so as not to depend upon the wall for support, as putlog-holes are not allowed in masonry. The scaffolding is usually formed nowadays of square timbers connected by bolts and irons. If the building to be erected is a large one, the materials are raised to the scaffolding by means of a travelling crane, which consists of a double travelling carriage running on a tramway; otherwise the materials are carried up in the usual way by pulleys and hods.

Shaping the stone.—The mason first knocks off superfluous stone along one edge of the block he is working until it is straight. This is called a **chisel draught**, *ab*. He then makes another such draught along one of the adjacent edges, *bc*; and then the ends of these two are connected by a third draught, *ac*. A fourth draught, *bd*, is next sunk across the last. Working from the point *d*, the edges



da and *dc* can be formed. The stone is then knocked away between these draughts, and then a plane surface is formed. Cylindrical or moulded surfaces are more difficult to work, while spherical surfaces require still greater skill.

Joints.—If masonry is to be secured more effectively than by mortar, joints such as **joggles** or **dowels** are used.

Stones are joggled together when a projection on one stone is made to fit into a groove on the other, or when a hard piece of stone is let into corresponding grooves in the two stones which are to be joined together.

Dowels are pins of wood or metal used to secure joints of stone-work in exposed situations, as copings, pinnacles, &c. Stones are also frequently bound together by molten lead, or by cement let into the grooves and apertures.

FORM.

Lines.—If two points be marked on the black-board, the *shortest* line which can be drawn joining these two points is a *straight line.* Draw two lines AB and CD.

A————————B C————————D

If when AB is placed upon CD, with the point A directly over C, the point B comes directly over D, we say the two straight lines AB and CD are *equal* to one another.

The two lines drawn above are also said to be *in the same direction,* because if AB were continued it would form CD.

If one line is placed under the other, the two lines being

A————————B

C————————D

as far apart at one end as at the other, they would never meet if drawn out ever so far.

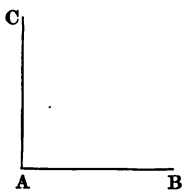
These lines are said to be *parallel* to one another.

Lines that are neither in the same direction nor parallel

are said to be *inclined* to one another, as AB and CD above.

Such lines will meet if produced.

Angles.—When two lines which are inclined to one another are produced and meet, the space between them is called an **angle.**



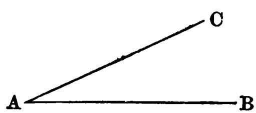
Right Angle.

Suppose there were two pieces of wood united by a hinge at A. By moving one of the pieces of wood, we could make the angle larger or smaller as we pleased.

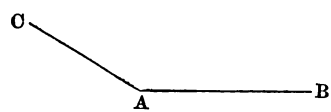
We could start with the side AC being upright to AB.

The angle thus formed is called a **right angle.**

If the two pieces of wood were separated by a smaller space as in the next figure, the angle would, being less than a right angle, be called an **acute angle.**



Acute Angle.

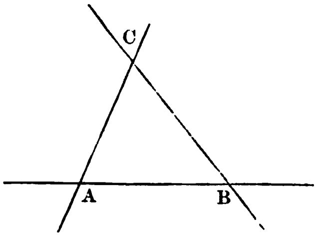


Obtuse Angle.

If AC were moved farther to the left, and the angle were made larger than a right angle, it would be called an **obtuse angle.**

Triangles.—If three straight lines intersect in three distinct points, they inclose a space which is called a **triangle.**

The straight lines AB, BC, CA are the *sides* of the triangle; AB is called the *base* of the triangle. The angle opposite to the base—that is, the angle formed by the sides AC and CB—is called the **vertical angle**. The other two angles of the triangle, namely those at A and B, are the *angles at the base*.



When all the three sides of a triangle are equal in length, the triangle is said to be **equilateral**.

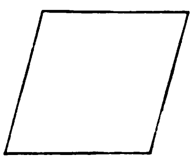
When two of its sides only are equal, it is **isosceles**.

When its sides are unequal, it is a **scalene triangle**.

Quadrilaterals.—Figures inclosed by four lines are called **quadrilaterals**.

The following are quadrilaterals:

1. A **square**.—It has all its sides equal, and its angles right angles.

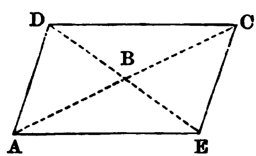


Rhombus.

2. A **rhombus**.—It has all its sides equal, but its angles not right angles.

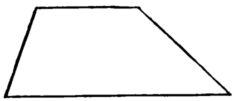
3. An **oblong** has its opposite sides equal, and its angles right angles.

4. A **parallelogram** is a four-sided figure whose opposite sides are parallel. Every parallelogram can be divided into two equal triangles by the straight line which joins two opposite angles. This straight line is called a **diagonal**.

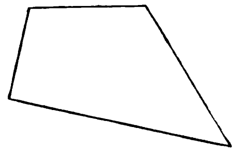


The dotted lines in the figure are diagonals. They bisect one another, that is to say, AB is equal to BC, and DB is equal to BE.

5. A **trapezoid** is a four-sided figure which has only two opposite sides parallel.



Trapezoid.



Trapezium.

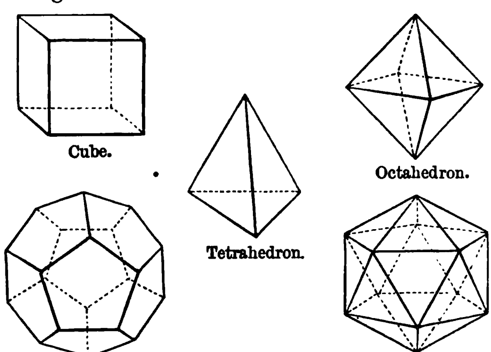
6. A **trapezium** is the name given to any other four-sided figure.

Solids.—A solid has *length*, *breadth*, and *thickness*.

The solid which has the least number of sides or surfaces is the triangular pyramid or **tetrahedron.** It is bounded by four equal and equilateral triangles.

The **cube** has six faces, all of which are squares. Each face is bounded by four lines.

The **octahedron** has eight faces, all being equal and equilateral triangles.

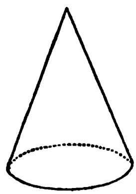


Cube. Octahedron. Tetrahedron. Dodecahedron. Icosahedron.

The five Regular Solids.

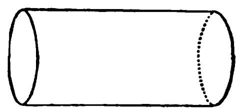
The **dodecahedron** has twelve equal faces called pentagons or five-sided figures.

The **icosahedron** has twenty faces, all being equal and equilateral triangles.



Cone.

A **cone** is a solid having a circle for its base, and tapering off to a point called the vertex.



Cylinder.

A **cylinder** is a solid whose two ends are equal and parallel circles. Besides these two ends, which are commonly called its two bases, it has but one curved face.

COLOUR.

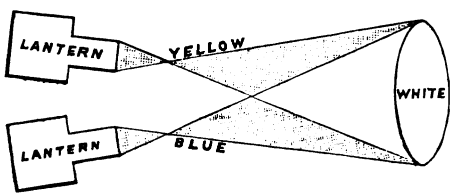
White light is a mixture of several different coloured lights.—Sir Isaac Newton discovered this. Into a dark room, through a hole in the closed shutter, he admitted a thin sunbeam. This beam of light passed across the dark room, and made a round bright image upon the opposite wall. In the path of the beam, Newton next placed a solid triangular piece of glass called a prism; and then, to his astonishment, instead of seeing a round bright patch of light, as before, he saw that it was drawn out into an oblong strip about five times as long as broad. Instead, too, of being white, this strip was divided into bands of different colours, namely, red, orange, yellow, green, blue, indigo, and violet.

These colours, as may be seen in the rainbow, blend into each other so gradually that it is difficult to say exactly where one ends and the other commences. The dark crimson at one end gently brightens into scarlet, this runs into orange, the orange becomes more yellowish, then yellowish-green, then green, greenish-blue, and violet.

All the seven colours named above were formerly said to consist of various combinations of *three* different coloured lights, red, yellow, and blue. These three colours were therefore called the **primary colours**, because it was thought that none of them could be formed by mixing together any other colours. It was, however, discovered in 1860 that yellow could be produced by a mixture of red and green; and hence yellow is no longer regarded as a primary colour. The three primary colours, as now recognised, are *red*, *green*, and *violet*.

Mixture of colours.—Coloured lights may be so mixed as to form white light. This may be shown by such an arrangement as the following: Plates of coloured glass are introduced, in place of the usual slides, into two magic lanterns so arranged that their light is focused on the same screen. In this way, there is thrown from each lantern upon the screen a bright circle of coloured light.

Suppose the light from one lantern is *yellow*, and that from the other is *blue*, the light formed by the mixture of



these two will be *white*. This will show that blue and yellow lights together form white. This same is true of red and green. Any two colours which by their union produce white light are called **complementary** colours.

If, however, blue and yellow *paints* be mixed together,

green (not white) will be the colour produced. There is therefore great difference in this respect between paints and light.

If the rainbow colours be painted on a circular piece of pasteboard, and arranged in their proper order and proportionate width, they will, when the pasteboard is whirled rapidly, blend together, and appear white to the spectator.

All **hues** of colours are produced by mixing primary colours in varied proportions.

By diluting these hues with white, all **tints** are produced.

By toning the hues with black, all **shades** are produced.

How the colour of most objects is produced.—The colour of a body is usually due to the action of its particles upon the white light which falls upon it. If the position or nature of these particles be altered, the colour of the body is often altered also. Thus the change produced in the particles of a piece of bread by toasting causes a change in colour also from white to brown.

According to the portion of light which the particles reject, so will the colour of the body be. Thus a red object is one in which the green part of the white light has been absorbed, and the red part reflected back to the eye. The light which falls upon a red flower may be exactly the same as that which is showered upon its green leaves, but because this light is acted upon by the particles of the flower in a manner different to that exercised by the particles of the leaves, the colour seen by us is different in the two cases.

A body is white when it is so constructed as to reflect all the seven colours. Black is caused by the absorption of all the colours, and is therefore the absence of colour.

Colours of a soap-bubble.—At first a soap-bubble is destitute of all colour and quite transparent. Then faint green and rose tints appear. As the bubble expands, the colours become more brilliant, and blue, orange, purple, yellow, and green take the places of the former colours.

The thin layer which forms the bubble has a sifting action on white light; certain rays are struck out, and the white light, being deprived of these rays, becomes coloured.

Colours of certain animals.—Colours produced in the same way as in the soap-bubble are seen in the feathers of the peacock, and the horny cases of beetles and of certain flies. The bodies of many fishes, too, and the surface of shells are adorned with rainbow colours similarly caused.

Colours of thin plates.—Any thin layer will produce rainbow colours. If two plates of dry glass about the size of a shilling be pressed together very tightly, the thin layer of air between them will be richly coloured—the colours varying according to the pressure with which the two are squeezed together.

Old glass which has remained buried for a long time tends to split up into flakes. By each of these numerous layers or flakes the light is reflected, and so when it reaches the eye it is many-coloured and bright.

The eye.—The eye is a round hollow chamber filled with clear transparent liquid. At the back of this chamber are many nerve fibres which come from the brain in a bundle called the optic nerve. If this optic nerve be excited, as it may be by pressure upon the eyeball, a bright flash of light seems to pass before the eye. Various colours, resembling a display of fireworks, may also be made to appear by a blow upon the eye. Anything, therefore, that stimulates the optic nerve may produce the sensation of colour. It is, however, by the agency of light that the optic nerve is

usually excited. Light enters the transparent front of the eye, passes through the fluids which the eye contains, and then strikes against the delicate coat which lines the back of the eye, and which is called the retina. It is here, namely in the retina, that the light stimulates the minute terminations of the optic nerve.

Complementary colours.—The retina is soon tired. If we look long at one colour, the eye becomes wearied by that colour, and can no longer see it. The colour, therefore, that is now seen is the complementary colour of the previous one. Thus, suppose we look long with one eye at a bright red wafer stuck upon a sheet of white paper. When we turn the eye from the red .wafer to the white paper, a greenish spot will appear about the same size and shape as the red wafer. The red image has tired the eye, and the part of the retina upon which it fell has become insensible to this colour. When white light now falls upon the eye, therefore, the red rays produce no effect, and so the remaining rays make up a green.

Colour-blindness.—Some people are unable to distinguish one colour from another—red and green are both alike to them; ripe cherries appearing in their eyes of the same colour as the green leaves. Such defect in vision is often inherited from a parent, and may be shared by several members of the same family. Dalton, the great English chemist, was so colour-blind as to be unable to distinguish between green and red.

In other cases, persons, while being able to recognise the primary colours, exhibit inability to distinguish the different tints; thus a violet-gray, for instance, appears the same as a bluish-gray.

APPENDIX.

NOTES OF A LESSON ON WATER.

It is a fluid.—Here is a glass full of water. Notice these things about it:

1. If the glass is not held upright, the water will flow over the sides.

2. If water be poured from tumbler into saucer, and from saucer into narrow bottle, it will alter its shape to suit the form of each vessel.

3. This little wooden pail has a hole in the side; into this a cork is fitted. Fill pail with water and pull out cork. Water flows out in a jet; water therefore presses on sides as well as on bottom of pail.

Throw a piece of cork into a glass of water—cork floats. Water is therefore pressing *upwards*, otherwise the cork would sink to bottom, and the cork is lighter than the quantity of water it displaces.

The scholars can now give the following reasons for calling water a fluid:

Because (1) It flows.
(2) It has no shape of its own.
(3) It presses in all directions.

The condition of water is altered by heat.—This test-tube is filled with water. A cork is fitted into it, and a piece of fine glass tube passes through the cork. The test-tube is first warmed—the water rises higher and higher in the small tube. (This is better seen if the water is coloured,) By-and-by the water boils—the steam requires more room—cork may be forced out just as lid of kettle is often lifted.

Test-tube next surrounded by ice—water contracts for some time—then for a little while gets bigger again until it becomes ice.

If thermometer is in the water, it will show points where changes

take place. When water boils, it will stand at 212°; when it freezes, 32°; when it expands just before freezing, 39½°.

The scholars should have learned:

1. Water, when heated, expands.
2. Water changed into steam, requires a great deal more room.
3. Water, when chilled, contracts.
4. Just before water changes into ice, it expands again.

Sources of water.—Where do we get water to wash with and to drink?

1. 'From the tap'—pipes—great tanks or reservoirs—river or lake.
2. Where no 'tap,' as in some country villages, how get water?

(*a*) Rain-water not so clean as water from tap. Where dirt comes from. Little bits of dust floating in air—dirty roofs, where rain fell, &c.

(*b*) Springs and wells. When rain not caught in buckets, &c., soaks into ground—sinks lower and lower—comes to hard rock or one like clay—cannot pass through—there stops and accumulates. If a hole be made down to this water, it may be got up by bucket or pump.

Summary to be drawn from the scholars.

The water we use is rain, which we get either—

(1) As it falls; or
(2) from rivers; or
(3) from wells and springs.

Uses of water—*for Drinking:*

1. Thirst worse than hunger. Compare time man might live without food, with that during which he could live without water—why we must have water—body composed largely of water, and constantly losing it. Touch a bright mirror—damp mark made—this shows water is passing from skin. Breathe on mirror—it becomes dim—this shows water is given off in the breath. Water which body thus loses must be made up. Hence we must drink.

2. Glasses of good and foul water compared.

Notice about the former:

(*a*) Clearness and brightness.
(*b*) Freedom from smell.
(*c*) " " taste.
(*d*) Pale blue tint.
(*e*) A drop of Condy's Fluid colours it.

Show saucer upon which good water, and another upon which foul water, has been evaporated. Compare residues.

3. How render foul water pure. If it is strained through fine strainers, the little bits of dirt may be kept back. Layers of sand, gravel, and charcoal are such strainers. Draw a figure of filter, and explain action. Add that charcoal, besides straining back impurities, destroys some of them.

The scholars should be able to answer such questions as:

1. Why we need to drink.
2. What drinking-water should be like.
3. How foul water can be made pure.

For Washing.—Wash hands in water from tap in London—soap-suds form thick curd on top. Notice difference when rain-water is used. One water is hard—other soft. What this means. From whence hard water gets lime. How lime may be removed. Furred lining of a kettle.

NOTES OF A LESSON ON THE HORSE.

Parts of the body.—Point these out on picture, or sketch upon blackboard. Give correct names; for example, withers, croup, &c.

1. *Head.*—What it contains—what brain is for—what happens if it is injured—eye—nostrils wide open, suited for rapid breathing, necessary for violent exercise.

2. *Chest.*—What it contains—use of lungs and heart—the girth.

3. *Legs.*—Feet, only one perfect toe each—hoofs really long nails. Height—how measured.

4. *Coat.*—Changes once a year—colour. Tail and mane.

Scholars should know:

1. *Body.*—Chief parts: (*a*) Head, where brain is; (*b*) Chest, where heart and lungs are; (*c*) Belly, where food is digested.

2. *Feet.*—Single perfect toe, inclosed in hoof.

The scholars should be able to point out when asked—Crest, withers, shoulder, hip, croup, fetlock, hoof.

Food and feeding.—Name articles of horse's food. What happens to food in the mouth? Teeth. Horse, like ourselves, has two sets. Front ones of second set have, at first, deep pits in which food leaves black mark. When horse about eight or nine years old, these teeth get worn down, pits and black marks disappear.

Between front teeth and grinders, there is a space in both jaws. It is in this space the bit rests. Horse has very small stomach. Should not be allowed to drink at all times.

Scholars can be led to suggest:

1. Why we should not 'look a gift horse in the mouth.'
2. When the horse should not be given large draughts of water.
3. What advantage it is to the animal to have a small stomach.

Locomotion.—Tell children to watch a horse starting to walk. Notice which legs move first. Hind-leg—fore-leg of same side—hind of opposite side—fore of that side. Rate of walking.

1. *Trot.*—Hind-leg moved at same time as opposite fore.

2. *Gallop.*—Succession of leaps—both feet off ground at same time—length of stride.

3. *Canter.*—Not quite a gallop.

Habits.—Horse not generally spiteful—easily frightened. When obliged to fight, uses teeth and heels.

Wild horses—how caught—bear fatigue well.

Horse not so intelligent as dog—yet knows what is said—this seen with plough-horses. Also shows affection—this especially case with Arab horse. Brain does not require much rest—four or five hours' sleep sufficient—method of sleeping—evils of prolonged standing.

Scholars can now tell how horse:

1. Shows spitefulness.
2. Shows intelligence.
3. Generally takes sleep.

History of the use of horse.—Horse not in common use among Hebrews—David—Solomon. Assyrians used horse, but not as beast of burden—this shown in representations on monuments—Greeks used horses for war and chase—no bit or bridle—Romans used bit—neither Greeks nor Romans shod horses—stirrup used at Norman Conquest—so represented on tapestry.

Scholars can give:

1. Use to which horse is now put.
2. Dress of horse.
3. Need for shoeing.

NOTES OF A LESSON ON THE APPLE.

The apple-blossom.—Make a vertical cut through the flower. Note following parts:

1. Calyx made up of five sepals *united together.*
2. Corolla made up of five petals, not united, but *separate.*
3. Many stamens.
4. Pistil made up of five carpels slightly combined.
   The stigma is the upper part of each carpel.
   The ovary containing the ovules is the lowest part.
   The style is the middle part.

Uses of the parts.—The stamens and pistil are the essential parts.

The sepals and petals are for the protection of these essential parts.

From anthers pollen grains reach the stigma. When there, each grain grows out into a tube which extends down the style to the ovary. Along this tube a substance from the pollen grain passes and fertilises the ovule.

The apple.—Note shape, colour, &c. At top is a trace of part of the calyx and perhaps, too, a few withered stamens.

At base of apple is the stalk.

Cut apple across. Note: (1) Rind; (2) Pulp; (3) Core.

The core is five-celled, the cells being formed by the five carpels. Each cell contains a pip or seed. Each seed has a brown outer covering, and is white inside. When placed in the ground, this pip or seed will grow.

The pulp is the thickened fleshy top of the flower-stalk.

Cider.—Made in certain western counties of England. The apples are ground up—the juice expressed and allowed to ferment. One acre of orchard land sometimes yields enough apples to produce twenty hogsheads of cider.

Cider highly valued as a drink, especially in earlier times.

The apple-tree.—Grows best on hill-sides. Damp soil unsuitable. 'Blight' caused by caterpillars destroying the blossom.

Wood suitable for turning. Dye extracted from bark. Apple-tree grows in most temperate climates. Known and used in this country for many years. Apple fritters of the middle ages. Probable origin of our cultivated apple-tree.

NOTES OF A LESSON ON AIR.

Air has weight.—Here is a glass globe. Quite empty, you will say. Not so, however. How prove this? Weigh it, and write down its weight. Now warm it over spirit-lamp, and while it is being heated, draw out and close end of tube. The warming drives some of the air out of the globe. Weigh once more; the globe will be found lighter than before.

By means of bellows, blow against one of the scale-pans of a balance at rest. The scale-pan blown upon, descends. In same way, a card-house blown at, is overturned.

Scholars can give us reasons for saying that air has weight:

1. A vessel from which air has been driven weighs less than it did before.
2. Air in motion exerts force.

Pressure of the atmosphere.—Because air has weight, the larger the amount of air, the greater will be its weight. What the atmosphere is. Its probable extent. Pressure resulting from this great weight. Experiment with leather and stone. What keeps sucker and stone together? Pressure of atmosphere about 15 lbs. on square inch.

Dip a glass tube in water and draw the air out of the tube. Water rises. Why? By application of same principle explain, with drawing, the action of a common pump.

Air inside our bodies—not only in lungs, but in every part. This pressing outwards equally with pressure of atmosphere—neither is felt by us.

Scholars should tell:

1. What the atmosphere is.
2. How we can demonstrate its pressure.
3. Why water rises in a pump.
4. The amount of pressure the atmosphere exerts.
5. How it is that our bodies are not crushed by this great pressure.

Air is compressible.—Syringe full of air. Stop hole with finger, and press down handle. Air inside can be squeezed into smaller space. Air thus squeezed is made denser. Air around us is squeezed by pressure of air above; therefore it is denser than that at tops of mountains, &c.

Scholars can be led to state:

1. What changes we should find in the atmosphere if we climbed a mountain or ascended in a balloon.
2. How these changes would affect us.
3. Why we should be so affected.

Air expands when heated.—India-rubber bladder only partly filled with air. Place at some distance from fire. Air in bladder becomes warmed. Particles driven farther apart. Bladder now appears full. If next put in cold place, once more shrivels.

Scholars can reason out:

1. Why heated air ascends.
2. How winds may be produced.

Composition of the air:

1. *Oxygen and Nitrogen.*—Burn a little phosphorus under bell-jar over water. After all smoke has disappeared, note visible change. Water has risen up one-fifth of the height. Introduce lighted match —it goes out.

Explain that by burning the phosphorus you have removed from this air a very important gas—oxygen. The gas which is left is chiefly nitrogen.

Contrast the two. Have large stoppered bottle of oxygen previously prepared. Show how rapidly a burning splint is consumed in it. Tell that by burning wood in oxygen a gas called carbonic acid is produced.

2. *Carbonic Acid Gas.*—Demonstrate its presence in the air we expire, by breathing into a tumbler of clear lime-water. Tell scholars beforehand what is going to happen, and why. Now shake up large jar of air with some lime-water. Illustrate poisonous effects of excess of this gas by references to the suffocation of miners which often occurs after an explosion. Also by descriptions of such instances as Poison Valley of Java. How the accumulation of this gas in the atmosphere is avoided. Work of green leaves and sunshine.

3. *Watery Vapour.*—Place in a glass vessel ice or iced water; a dew is deposited on outside. How the amount in the air is increased. Evaporation. Influence of temperature upon the amount of vapour the air can hold. Condensation explained.

The scholars should know:

1. Of what air is chiefly composed.
2. The two most important ingredients—their proportionate amounts.

3. Effect of oxygen upon burning things.
4. Effect of nitrogen upon burning things.
5. Effect of carbonic acid gas upon burning things.
6. What becomes of much of this carbonic acid gas of the atmosphere.

NOTES OF A LESSON ON THE FARMER.

What the farmer does.—Ascertain if any of the class have spent a week or two in the country. What work have they seen being carried on in the fields? Different answers given according to time of year at which visits were made. Ploughing, harrowing, or sowing; or perhaps haymaking or harvesting. All this work done by farmer and his labourers. Ask if any boy or girl has lived at a farm-house. Get description of daily work witnessed. Up at four or five in morning—horses fed and groomed; cows milked; sheep, pigs, and poultry attended to—field work commenced—indoors during daytime, perhaps butter and cheese making—in evening, horses groomed and fed, sheep penned, cows milked, &c.

The farmer's implements.—Show picture of plough. Point out its parts—the ploughshare, the beam and its handles, and the wheel. Describe the use of each of these parts, and the mode of working of the whole. The grubber. Point out the construction on picture, and describe use. The harrow. Show picture. Describe use of teeth in scratching the soil, turning over clods and breaking them. Show pictures of the clod-crusher, drilling machine, and horse-hoe, and explain use of each.

What the farmer grows.—*Grain crops.*—Name wheat, barley, oats, and rye. Describe sowing and reaping.

Fodder crops.—What fodder is, and how grown. Haymaking—when it takes place and what is done. Ensilage, another method of preserving grass, &c.

Root crops.—Name turnips, carrots, and parsnips, mangold-wurzel, and potatoes. When each is sown or planted, and the treatment each requires.

The cattle the farmer rears.—*Horses.*—Breeds, feeding, accommodation.

Cattle.—Breeds, use, management, feeding.

Sheep.—Breeds, value, mode of feeding.

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THE END.

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